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Introducing Design for Six Sigma's DMADV Methodology to the Packaging Industry

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Introducing Design for Six Sigma's DMADV Methodology to the Packaging Industry

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ABSTRACT

The purpose of this thesis was to introduce a standard method for designing efficient and sustainable packages to the packaging industry. This thesis has focused on how a standardized process has helped to design efficient, cost-effective and sustainable packages in the food industry. The standardized process used was the lean six-sigma methodology called DMADV. The DMADV methodology has been implemented for inventing and innovating major new features of existing products, services or processes.

The main objective of this research was to:

1. Introduce the lean six-sigma DMADV methodology to the packaging industry.
2. Show how a DMADV methodology can be implemented for designing efficient and sustainable packages that will satisfy the consumer and would have less environmental impact.

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Introduction

Currently, most organizations are showing keen interest in using the Six Sigma approach to improve the performance of their operations. Motorola invented the concept of Six Sigma, and General Electric made it popular. Design for Six Sigma (DFSS) is a method used by Six Sigma project teams to invent and innovate products, services, and processes.

There are two approaches for implementing Six Sigma. The first approach is the DMAIC approach. DMAIC stands for Define, Measure, Analyze, Improve, and Control. The second one is the DMADV approach, which stands for Define, Measure, Analyze, Design, and Verify. DMAIC is used when a product or process is in existence in a company, but it does not meet customer specifications, nor is performing adequately. DMADV is used when a product or process does not exist and one needs to be developed, or when the existing product or process has been optimized, but still does not meet the level of customer specification or six-sigma level.

The DMAIC methodology is implemented for improving a product, service, or process, whereas the DMADV methodology is implemented for inventing and innovating a completely new product, service, or processes, or for inventing and innovating major new features of an existing product, service, or process. The DMAIC provides evidence-based solutions to issues of today, whereas DMADV focuses on the resolving issues of tomorrow. Both approaches are very critical to problem-solving within the packaging industry.

Although most of the packaging industry has not quite adopted the DMADV approach because of the abstract phases within the design process, the DMAIC process has been successfully embraced within the packaging industry. The last step in manufacturing is the packaging of the product, which is an important factor for transportation of the product. Thus, the designing of the package is the most important step. Industries still look at it as a product-in-

the-box approach. Rather, package design should be the first step to be considered, even before designing the product. It has been found many times that the package performs absolutely well, but the specific design of the product causes the damage to the product while in transit. If we could foresee damages with a current package design, we would have more safely delivered products. This is where DMADV comes in. DMADV deals with the issues of tomorrow.

In the Methods section of this thesis, a case study is used to show the implementation of Six Sigma using the DMADV approach. The study focuses on how the DMADV steps are used to solve the problems occurring during the package design process. Each of the five steps in the DMADV methodology are explained. The objective of this thesis is to show how a standard DMADV process would create eco-friendly packages by considering the entire lifecycle of the package -- starting from concept and structure, through manufacturing and distribution, and to the end of life. This will be a process that would satisfy the customer and have a low environmental impact.

The remaining sections (Results, Discussion, and Conclusion) of this thesis take on a non-traditional style. The traditional style focuses on the data and information learned in the Methods section. This non-traditional approach concentrates on showing how DMADV, combined with the Wegmans project, demonstrates an innovative way to design packages. The Results section proves the importance of this non-traditional approach. The Discussion section focuses on how the DMADV approach has helped to improve the Wegmans barbecue sauce package, and thus the relevance of this research in the packaging industry. The Conclusion section focuses on the conclusions that can be drawn from this research and suggests additional future work that can be conducted based on this research.

Thesis Statement

To introduce the lean six-sigma DMADV methodology to the food packaging industry for creating highly efficient package designs and improving the sustainability of the final product. This DMADV model will create packages that will meet the sustainable goals of the entire supply chain and will add value to the retailer, as well as to the consumer of the product.

Literature Review

The literature summarized in this chapter focuses on the effective use of DMADV in the packaging industry and on how DMADV would help in designing optimum packages. It also focuses on the research that provides information on different software, approaches, and methodologies currently used for designing packages. The literature has been gathered from different sources, such as *The Design for Six Sigma Handbook*, articles from Internet, and company websites. At times, communicating in person with industry experts has also helped in retrieving information.

After conducting the literature review, this researcher was able to identify the needs of the industry. The industry needs one standardized package designing process that can be used across the board. This gives the researcher confidence that his thesis topic is original and that the industry will soon reap the benefits of using this design process.

Source: Books, Websites, and Online Articles

Butschli, J. (2012, May 31). Inviting Packaging to the product development table. *Packaging World.* Retrieved from http://www.packworld.com/package-design/strategy/inviting-packaging-product-development-table

This article stresses the point that the packaging of the product must be considered in the early stages of its development. This proactive approach can help the packaging engineers to allow for innovation on the equipment side and a system as a whole. Developing packages at an early stage also allows co-ordination with Product Development, Marketing, Regulatory, Quality, Production, and Distribution. Packaging that makes compliance easy is extremely important to the product's success.

Medtronic also has an EHS (Environmental, Health, and Safety) Standard that requires that EHS considerations to be evaluated in the product development process; that includes meeting packaging EHS requirements and improving packaging sustainability opportunities.

Duotone. (n.d.). *Steps used for designing packages in the packaging industry*. Retrieved January 22, 2016, from http://duotone2.com/process-steps-default/process-steps-packaging-design/

Duotone uses these four steps to design a package:

Step 1 - Listen + Gather: Each company has its own perception in the minds of the customers. Package design directly affects the consumer's perception of the brand. The design engineer of Duotone listens to how their customers wants their business to be perceived in the market, and then gathers the appropriate tools to mold and elevate the brand image above their competitor's.

Step 2 - Prepare + Develop: Then by analyzing industry trends and market competitors, an initial design is created. Since each business is different, their personalized approach allows them to develop more effective designs for their customer's specific needs.

Step 3 - Design + Construct: In this phase, they transform the design objectives into the third dimension and work with local manufacturers to create a prototype.

Step 4 - Test + Present: In this step, the package is tested for its integrity. Once the design engineers are satisfied with the practicality of the design, they will give a presentation to the customer.

This is the very basic process of package design being used in the industry. There is much room for development. These are some issues that are not addressed in the above design process:

a) Do they use life cycle assessment (LCA) tools to evaluate the packages?
b) Are they looking for the package to be made reusable or recyclable?
c) Are they employing any strategies that could encourage product consumption?
d) If they are unable to come up with the design, are they considering making changes in the product, so that the packaging is more sustainable?
e) Do they take into consideration Federal Drug Administration (FDA) regulations while designing the packages, where conforming to the regulations is necessary?

All these issues / questions need to be addressed. A process needs to be developed that would create eco-friendly packages by considering the entire life cycle of the package, starting from concept and structure, through manufacturing and distribution, to the end of life. A process that would satisfy the customer and have a low environmental impact.

Johnson, A; Widener, S; Gitlow, H; Popovich, E; (2006). A Six Sigma Black Belt case study: Designing new housing at the University of Miami. *Quality Engineering, 18,* 3. Retrieved from http://www.howardgitlow.com/gitlow%20point%20of%20view.html#Micro Model - Six Sigma DMADV Model

The authors described the efficient use of the DMADV model to design a new dormitory at the University of Miami.

Define Phase: To create a design for a high-class living facility that encourages learning and community (product) aimed at executives-in-residence, MBA students, as well as junior and senior undergraduate business students (market segments) to increase (direction) the number of on-campus residents (measure of success) by 280 students (target) by July 15, 2008 (deadline).

Measure Phase: The designers used the Kano Model of Customer Satisfaction and performed a survey using the features identified from the focus groups.

Analyze Phase: In this phase, five room designs were developed according to the group preferences. They were Undergraduate Preferences, Graduate Preferences, Eaton Hall, Business Suite, and Luxury Suite. These five designs were then graded on the basis of six different criteria determined by the team members. The Graduate Preference design was found out to be the best design. After performing the Risk Analysis on it, seven potential serious hazards were found. Some changes were then made to the design.

Design Phase: In this phase, a detailed design of the best design from the Analyze Phase was created, along with the verification plan to enable a smooth functioning of the affected departments.

Verify/Validate Phase: In this phase, a control and transition plan was designed, and the project was concluded.

Since DMAIC did not work in the first place, DMADV was implemented because the process did not yield the expected results. So can we use DMADV for designing

packages in the Packaging Industry? Can the current package designing process be optimized for creating eco-friendly packages by considering the entire lifecycle of the package starting from concept and structure to manufacturing and distribution to the end of life? Can a process be designed that would satisfy the customer and have a low environmental impact? In summary, use DMADV when you are trying to improve the process and it has not worked or delivered to your expectations, or when you want to develop something entirely new.

Mohan, A. M. (2012, November 2). Ten tips for sustainable package design. *Packaging World,* Retrieved from http://www.packworld.com/ten-tips-sustainable-package-design

Take a lifecycle approach to package design: Use Life Cycle Assessment (LCA) tools from those available in the market, such as COMPASS or Package Smart, so that the designers can evaluate the environmental impact of their selected designs and chose a better one.

Evaluate each component of the package: Continuously look for the changes that can be made to the package so that there is less use of the material without compromising the package integrity. Innovations are being made in containers, caps, labels, and other components to improve the package to product ratio, resulting in a smaller footprint, thereby making it sustainable and low-priced.

Consider new options for secondary packaging: In the distribution cycle, the use of less material to create bundles, multipack, and pallets is the need of the hour. New machines and technologies are helping the package engineers to achieve this milestone.

Also, creating a shelf-ready package that minimizes waste at the retailer level is currently the most important issue.

Look for opportunities where the package can be made reusable: When PUMA introduced its "Clever Little Bag," an attractive, reusable red shoe bag used to package its footwear, it reduced its paper consumption by 65%. PUMA estimated it would reduce water, energy, and diesel consumption at the manufacturing level by more than 60% per year.

Consider changes in the product: Sometimes it is necessary to consider the changes in the product in order to make the packaging more sustainable. Among the many examples are the basic ones, such as household cleaning products. Beginning with laundry detergents and rippling through other cleaner and chemical products, consumer packaged goods (CPGs) have turned to concentrated formulas to reduce the amount of water shipped from factory to retail shelf and to enable smaller package sizes. Perhaps the most compact of all; Method's 8X-concentrated laundry detergent formula can wash 50 loads per 20-oz bottle, and 25 loads per 10-oz bottle. Also popular in the cleaning products industry have been systems that combine concentrated product refills with reusable packaging.

Always try to design a package that can be recycled: During the manufacturing of packaging materials, much energy is consumed. One of the best ways to preserve this consumed energy is by making the material recyclable or by using recycled and recyclable materials for packages. For example, Seventh Generation launched its 4X-concentrated liquid laundry detergent in 2011. The container consists of a molded-pulp outer shell made from 70% recycled cardboard (OCC) and 30% old newspapers (ONP)

that can be recycled up to seven times. The package's inner film pouch with a spout has been constructed of polyethylene only, making it suitable for recycling with plastic grocery bags, while the pack's polypropylene closure is recyclable through Preserve's Gimme 5 recycling program.

Employ packaging strategies that encourage product consumption: According to the US EPA, 34 million tons of food is wasted every year. So a package that could guarantee a maximum consumption of the product would be considered to be more sustainable. For example, a mayonnaise package employs a nonstick surface on the inside of the container that provides the slip properties needed to get the last bit of mayonnaise from the jar.

Know where packaging materials come from. In this way, you can be sure that you are using responsibly sourced packaging material.

Evaluate the distribution system for space saving opportunities: A wasted space in packaging results in excess use of materials, transport, handling, and storage. A packaging engineer must understand the size of the transport mode that will be used, and then reduce the package size to hold everything at low cost so that he can minimize the package size while maintaining its integrity.

Consider materials made from renewable feedstock: Bio-plastics made from corn or sugarcane is a rapidly growing area. However, they still need to be checked for their sustainability, recyclability, and source, and for whether the packaging from renewable feedstock can provide the required functionality and integrity to the product.

Nolan, P. (2009, September 24). Six steps to developing packaging for medical devices. *Healthcare Packaging,* Retrieved from http://www.healthcarepackaging.com/package-design/structural/six-steps-developing-packaging-medical-devices

Nolan offers a six-step guide for coming up with package design in the medical device industry.

Step 1 - Consult the regulations. The manufacturer should make sure that the device complies with the FDA or other international regulations for packaging.

Step 2 - Gather Packaging Design requirements. The packaging designer should co- function with the respective project team members to document the design requirements.

Step 3 - Establish packaging system conformity requirements. The packaging system should ensure that the product reaches its end use in a usable and sterile condition. The package system must prevent any cracks or ruptures of the sterile barrier (for a sterile barrier package) and prevent damage to the medical device, which is not easily detectable and which may impact the safe and effective use of the device.

Step 4 - Investigate labeling requirements. All medical devices must be labeled as per the FDA regulations (21 CFR Part 801), which contains active subparts A, C, D, E and H. Subpart A - General Labeling Provisions, should be carefully reviewed for required compliance, as well as the remaining subparts to determine if special compliance is indicated.

Step 5 - Conduct distribution and handling tests**.** The package designer performs a thorough investigation of the anticipated distribution, storage, and handling conditions of

their medical device. This is typically performed in a laboratory using published standards that simulate the distribution environment.

Step 6 - Perform stability testing, accelerated and real-time aging of sterile barrier system. For medical devices, the industry-recognized compliance standard, ISO 11607(1) and (2): 2006 requires stability testing of the sterile barrier system.

The manufacturers execute whole package and seal integrity test at specific intervals of time throughout the accelerated aging and real-time aging protocols. This helps them in evaluating age-related phenomena to the whole package and seal integrity.

Although this six-step guide tries to cover maximum design considerations, it has still missed some of them. This guide addresses the issues related with distribution and handling, product integrity, labeling, and regulations. However, it fails to address some questions, including these:

a) How is the package evaluated? Do they use LCA tools to evaluate the packages?
b) Are they looking for the package to be made reusable or recyclable?
c) Are they employing any strategies that could encourage product consumption?
d) If they are unable to come up with the design, are they considering making changes in the product, so that the packaging is more sustainable?

Tom. (n.d.). The packaging design process and why our package design process always leads to successful product sales. Retrieved January 22, 2016, from http://www.cummingsdesign.com/Packaging_Design_Process.htm

Tom offers this three-phase design guide:

Phase 1 - Research and Competitive Package Design Evaluation: The package designer visits a retail store and takes photos of the aisle and competitive products, studies the shelf placement and tries to determine the best placement for the product, i.e. top, eye level, or bottom. The designer aims to get the customer brand recognition with the package design in colors and design elements.

The designer points out the two fatal mistakes made by amateurs, which may sometimes end up in a lawsuit. The mistakes occur when amateurs imitate a famous package design or overlook a competitive package design.

The designer uses Pantone Matching System (PMS) standard colors to have a good color reproduction, and also uses Adobe Illustrator for good graphics quality.

Phase 2 - The design refinement Phase: After the desired package design has been selected from many of the designs developed in Phase 1, some minor changes, if required, are made to arrive at the final design. The design must now be tested for distribution. The designer is aware of the FDA regulations and suggests following them.

Phase 3 - The Production Phase: After the client has approved the final design, the designer works with different vendors to make sure the package is manufactured according to the client's specifications. Also the copyright issue is taken care of. The package is also checked for its manufacturability.

This guide addresses the issues related with market research, distribution and handling, product integrity, package manufacturability, labeling, and FDA or International regulations. However, it fails to address some questions, including:

a) How is the package evaluated? Do they use LCA tools to evaluate the packages?

b) Are they looking for the package to be made reusable or recyclable?

c) Are they employing any strategies that could encourage product consumption?

d) If they are unable to come up with the design, are they considering making changes in the product, so that the packaging is more sustainable?

From the above design guide that comes from different areas of industry, many loopholes are identified. There are many questions that are not addressed which might create problems in the future for this package. This means that the package is going to need an improvement in the future. This is the reason why Packaging industry is still using DMAIC. The DMAIC methodology is implemented for improving a product, service, or process. The packaging industry needs a vision. If we could foresee the damages with the current package design, we would have more safely delivered products. This is where DMADV comes in. DMADV deals with the issues of tomorrow.

Spinner, J. (n.d.). BBQ pack revamp wins RIT student packaging contest. Retrieved January 14, 2016, from *Packaging Digest:* http://www.packagingdigest.com/packaging-design/bbq-pack-revamp-wins-rit-student-packaging-contest

This article focuses on a project that was developed by a group of inter-disciplinary students at Rochester Institute of Technology to enhance the current packaging of the Wegmans BBQ sauce bottle.

Existing Bottle: The current BBQ sauce bottle comprises glass material, a metalized cap, a paper label, and tamper-evident shrink-wrap. To begin, a SWOT analysis of the current package was performed. Glass conveys high quality, but it's heavy, rigid, and breakable. Also, the glass bottle has low cube efficiency. Additionally,

the dispensing of the BBQ sauce is not efficient, thereby leading to product waste. The students applied a six-sigma process to come up with new efficient bottle design.

New Bottle: The new bottle is made up of plastic (PETE), PP closure, and LDPE orifice reducer. The orifice reducer facilitates a controlled flow of the BBQ sauce, thereby reducing the product waste. The design improvements are remarkable.

The cube efficiency of the bottle has increased with a reduction in package-to-product ratio. The cubicle shape of the new bottle makes it possible to ship a bigger number of bottles per truck, as opposed to the old bottle design. Considering the larger picture, seven fewer trucks were needed to ship 1 million bottles. Also, the use of the orifice reducer eliminates product waste.

This strikes a new idea of using lean six-sigma methodology in the packaging industry for creating cost-effective, efficient, and sustainable packages.

Source: Personal Meetings

While at the Pack Expo, Chicago, 2012, this researcher had a chance to meet some of the professional package designers from the industry.

ALGUS Packaging Inc. (http://www.algus.com/)

Algus is an established manufacturer of sealing machines, thermoformed packaging and full service contract packaging. The designer said that they mainly focus on these issues while designing a package:

- Manufacturability
- Sustainability (Wal-Mart Score Card)

- Profitability
- They also perform audits for the supplier to match to their standards

SONOCO (http://www.sonoco.com/)

Sonoco is a multi-billion dollar global provider of consumer packaging, industrial products, protective packaging, and packaging supply chain services. While discussing with one of the package designers, the researcher came to understand that there are these certain areas on which they focus:

- Shelf -Life
- Reclosability
- Portion Control
- Performance
- Mechanical
- Chemical
- Store Considerations
- Is the customer interested to pay?
- Is the packaging Money driven or Market Driven?

North American Packaging Alliance (http://www.northamericanpackagingalliance.com/)

The designers from this company mainly focus on:

- Product Characteristics
- Shelf Life
- Retailer Guidelines

- Modern Machinery available
- Product to package compatibility
- Distribution Environment
- Manufacturability
- Customer Requirements
- Shelf life of the package required

The summary of the literature review demonstrates that there is no such standardized process to develop packages. The packaging industry needs an exceptional standardized process. This type of standard process would create eco-friendly packages by considering the entire lifecycle of the package starting from concept and structure, through manufacturing and distribution, to the end of life. The industry needs a process that would systematically consider regulatory requirements, customer needs, and environmental impacts.

Additionally, while conducting the literature review, it was observed that six sigma methodologies could be of a great guidance while designing Package Design Model. The Methodology section focuses on the use of a lean six-sigma methodology called DMADV to come up with an efficient and cost-effective package design process.

Methodology

Based on the Literature Review, it is observed that there is no reliable standardized process that is being used to design packages. By using some of the methodologies from lean six-sigma, like DMADV, an optimized package designing process can be developed. This section focuses on the use of a lean six-sigma methodology to design packages efficiently.

Let us first understand what is lean six-sigma? What are the commonly used methodologies in lean six-sigma (i.e., DMAIC, DMADV)? And when should one use DMAIC v/s DMADV? By the end of this section, it will be very clear how a DMADV methodology can improve a package redesign process.

Introduction to Six Sigma

Six-Sigma is a business management strategy, which was originally developed by Motorola in 1981. Today it is being used in different industries, and several industries are enjoying its benefits. Six-Sigma uses a data-driven approach for eliminating defects in any process. It aims at meeting the customer's requirements by implementing a measurement-based approach that reduces variation through process improvement projects.

Six-Sigma helps to identify the cause of the problem to efficiently develop effective solution. By using Six Sigma, the amount of defective products or services will be reduced, thereby increasing revenue and customer satisfaction.

Benefits of Using Six Sigma

Implementing Six Sigma within a business offers several benefits, including:

- Increased revenue
- Decreased organizational cost
- Improved efficiency and effectiveness
- Increased customer and employee satisfaction
- Enhanced reputation
- Improved supply chain management

DMAIC v/s DMADV

DMAIC and DMADV are two of the most widely used Six Sigma methodologies. Both these methods help make the business process more efficient and effective. Although both of these methodologies share some important characteristics, they are not interchangeable and were developed for use in differing business processes. Before comparing these two approaches in more detail, let us review what the acronyms stand for.

- DMAIC: Define, Measure, Analyze, Improve, and Control
- DMADV: Define, Measure, Analyze, Design, and Verify

How are DMAIC and DMADV Different?

Although the first three phases of both these methodologies are the same, there are some notable differences between the methodologies. The main difference is in the way the final two phases of the processes are handled. DMAIC states the applicability of the business process, whereas DMADV focuses on the customer needs as they relate to a service or a product. With DMAIC, the Improve and Control Phases focus on spot improvements and controlling the

process. It has a silo approach. In contrast, with DMADV, the Design and Verify phases deal with redesigning the process in order to meet the customer requirements

DMAIC concentrates on improving a business process in order to reduce or eliminate defects; DMADV develops an appropriate business process that will meet the customers' requirements.

When Should DMAIC and DMADV Be Used?

DMAIC is used when a product or process is already in existence, but is no longer meeting the customer expectations. DMAIC focuses on spot improvements at the problem area.

DMADV is sometimes useful for existing products and processes. In general, DMADV methodology is implemented for inventing and innovating a completely new product, service, or processes, or for inventing and innovating major new features of existing products, services, or processes. Both the approaches are very critical to run an organization smoothly. DMAIC deals with the issues of today, whereas DMADV focuses on the issues of tomorrow (Howard S.Gitlow, 2006)

The DMADV model is used to add new features to the existing packages or to develop entirely new packages. The five phases of DMADV are:

Define Phase. In this phase, a business case is developed, and the risk and the benefits of the project are understood. Then the team of people is created, the project plan is developed, and the project objective is written.

Measure Phase. This phase consists of three different steps: dividing the market into different segments, conducting a survey, and using the survey results as inputs to find critical-to-quality (CTQ) characteristics.

Analyze Phase. In this phase, a design is generated or the current design is analyzed for defects by using the cause and effect diagrams. Finally, nominal values are created for all the CTQ components for the best design.

Design Phase. In this phase, there are three steps: First, a detailed design is created of the best design from the analyze phase. Second, the capabilities of the process elements are estimated and developed. Lastly, a verification plan is developed so that there is a smooth transition between different departments.

Verify/Validate. This phase helps in designing a control and transition plan, and to conclude the DMADV project.

To implement the DMADV methodology in the packaging industry, a project was considered. This was the Wegmans barbecue sauce bottle that needed to be redesigned to improve user experience and boost sales. With the help of this example, it was shown how DMADV proved to be a significant tool in designing a new package for a current product.

The current package consists of a glass bottle, a metalized cap, a paper label, and tamper-evident shrink-wrap. The product suffered sales drop, so it was necessary to improve the sales. The primary goal of the project was to modernize its brand assets and strengthen its consumer appeal by addressing the customers' requirements. The customer requirements were:

1. Adding value to the packaging for the consumer
    a. Buying decision – increased visibility, faster and easier communication (shoppable)
    b. In-use and storage of the packaging
    c. End of life considerations

2. Sustainable Goals – primary and secondary packaging + shipping/storage considerations
    a. Sustainable use of packaging materials in the supply chain
    b. Promoting sustainable use of the product by the consumer
3. Adding value to the packaging for the retailer
    a. Reducing movement/handling in store of packaging
    b. Optimizing store shelf space

By applying the DMADV methodology, this problem was solved. The sales of the barbecue sauce were improved, along with reduced packaging costs. To achieve the goals set forward for improving the sales, the DMADV methodology was used. Each phase of the DMADV process used a different set of tools that helped to navigate through various phases of the process. This DMADV methodology below explains the steps taken and the tools used for each phase. The phase was marked completed once it reached the Tollgate review. The output of one phase served as an input to the next phase. The DMADV project described below had a seamless flow.

Define Phase

This was the first phase of the DMADV methodology where the project goals and customer (internal and external) deliverables were identified. The purpose of this step was to clearly identify the business problem, goal, potential resources, project scope, and high-level project timeline. A clear definition of the project was established during this step, and every strategy and goal needed to be aligned with the expectations of the company and the customers.

In order to develop and to validate the standardized package designing process, the Wegmans barbecue sauce bottle was used as an example. First, it is very important to understand the current package: What are the customer's expectations? And what goals are to be set in order to achieve those expectations? The Define Phase helped in understanding the customer's expectations and in setting up the goals to meet those expectations for the barbecue sauce package. By applying the Define Phase to the Wegmans barbecue sauce package, a business case was developed, and the risk and the benefits of the project was identified.

These tools were used in the Define Phase:

- Business Case
- SWOT Analysis
- Opportunity Statement
- Project Objective
- Project Scope
- Project Plan
- Project Charter
- Define Phase Tollgate Review

Business Case.

This was the first tool used in the Define Phase. A business case is a decision-making tool that formally describes the problem, the benefits, cost, and impact of the project to the organization. The purpose of the business case tool is to record the justification for starting a new six-sigma project in order to satisfy customer needs and to support business strategy. It helps to bring the leadership team/higher management on board with the project.

From the literature review section, it is clear that a standardized package designing process needs to be developed for the industry. Consider the Wegmans barbecue sauce package. The customer's requirements were that the package should add value to the consumer and the retailer, and should be sustainable. By evaluating the current glass bottle, it is very clear that there is much room for improving the current package. A business case needed to be developed that clearly describes the problem with the current package, benefits of the new package, cost and impact to the company.

The current barbecue sauce package consists of a glass bottle, a metalized cap, a paper label, and tamper-evident shrink-wrap. Glass is heavy, rigid and breakable; the bottle has low cube efficiency and generates product waste while pouring. Additionally, since the package is not aesthetically appealing, the package lost its shelf presence, thereby causing a decrease in the sales. By applying the standardized package designing process, a new improved package design was proposed. The potential advantages of the new design with respect to the current glass bottle are:

Design Improvements. The improvements made to the existing package design to make it more efficient, cost-effective and eco-friendly are termed, Design Improvements. From the packaging standpoint, this means:

1. Maximizing cube efficiency in order to ship more amount of product and less air.
2. Reduction in package to product ratio and primary package weight to reduce the packaging material consumption.
3. More number of primary packaging components per pallet and eventually truck to reduce fuel consumption.
4. Reducing any additional work in the entire supply chain of the product.

The Wegmans new bottle design would show the following Design Improvements:

1. Cube Efficiency: increased by 19%
2. Package to Product ratio: decrease by 83%
3. Primary Package weight reduced by 84%
4. Product on pallet increased by 312 bottles
5. Bottles per truck increased by 43%

Sustainability Improvements. The enhancement that is made to the existing product/package to reduce its environment impact and cut down product waste is termed, Sustainability Improvement. Sustainability Improvement focuses on:

1. Reducing the amount the trucks required to ship the product thereby reducing the CO_2 emission.
2. Maximizing use of recycled material for the package where possible.
3. Deployments of special packaging features that help reduce produce waste.

The Wegmans new bottle design would show the following Sustainability Improvements:

1. Seven fewer trucks needed for every million bottles
2. Reduced CO_2 emissions by 30%
3. Eliminated product waste by use of the orifice reducer

The new, improved package satisfies customer's requirements, i.e. the package should add value to the consumer and the retailer, and be sustainable. Additionally, with the new improved graphics, the new bottle design would have an increased shelf presence and would thereby boost sales.

From the business case, in order to propose a new bottle design, it is very important to understand the current bottle. To evaluate the current package, a SWOT (Strengths, Weaknesses,

Opportunities and Threats) analysis of the current package was performed. A SWOT analysis is the next tool in the process.

SWOT Analysis.

SWOT, which is Strength, Weakness, Opportunity and Threat, is a tool that helps an organization to understand its Strengths and Weaknesses and to identify its Opportunities and Threats[1]. The purpose of SWOT Analysis is to think about everything that could potentially impact the success of a new project. It also helps in avoiding making costly mistakes and determines which projects are most likely to succeed.

After creating the Business case for the barbecue sauce project, it is very important to evaluate the current glass bottle. The SWOT Analysis tool will help us to identify the strengths and weaknesses of the current glass bottle. It will also help us to identify the opportunities for improving the current glass bottle, as well as the threats with respect to market competitors. Therefore it is very crucial to conduct a SWOT Analysis of the current bottle.

The following framework shows a standard way of creating a SWOT Analysis for the current barbecue sauce glass bottle. It clearly outlines a list of the internal strengths and weaknesses that are relevant to the glass bottle, and then creates a list of opportunities and threats that exist outside of the company that could impact the project.

[1] SWOT Analysis Definition | Investopedia. (2005). Retrieved February 05, 2016, from http://www.investopedia.com/terms/s/swot.asp

STRENGTH	WEAKNESS
➢ Glass conveys high quality. ➢ Quality branding for private label. ➢ Competitively priced for glass category.	➢ Glass is heavy, rigid and breakable. ➢ The bottle has low cube efficiency. ➢ No communications on tamper-evident seal.
OPPORTUNITIES	**THREATS**
➢ Move from Glass to Plastic Bottle. ➢ Add Dispensing closure. ➢ Full rebranding of product line.	➢ Glass category: Dinosaur BBQ, Uncle Ralph's ➢ Plastic Category: Jack Daniels, Kraft Foods ➢ Consumer may not recognize new product.

From the SWOT Analysis, it is clear that there is an opportunity for improving the current glass bottle. Also as discussed in the Business case, the standardized package designing process would help to create cost-effective and sustainable packages. This is where a project needs an opportunity statement that clearly identifies the opportunities involved in this project. Opportunity Statement is the next tool used in the Define Phase of the DMADV model.

Opportunity Statement.

Opportunity Statement is nothing but a statement that describes the current and desired state of the problem, or opportunity, in clear, concise, and measurable terms[2]. The purpose of the opportunity statement is to outline the basic facts of the problem, explain why the problem matters, and pinpoint a solution as quickly and directly as possible.

From the SWOT analysis, it was observed that there is much room for improving the current barbecue sauce bottle. There is an opportunity to enhance the current barbecue sauce glass bottle by using the DMADV model for package designing. The Opportunity Statement tool helps us to describe the opportunity in clear, concise, and measurable terms. Given below is the opportunity statement for the Wegmans Project:

- *The current package is heavy, rigid and breakable. The glass bottle has a high cube efficiency and has no communication on the tamper-evident seal*
- *The desired state: An efficient package that is lightweight has high cube efficiency and low environmental impact. A package that will reduce product waste and will add value to every step of the entire supply chain.*

This great opportunity of redesigning a package can be turned into a project objective. Developing the project objective is the next step in the Define Phase.

[2] Gitlow, Howard S., David M. Levine, and Edward A. Popovich. *Design for Six Sigma for Green Belts and Champions: Applications for Service Operations--foundations, Tools, DMADV, Cases, and Certification*. Upper Saddle River, NJ: Pearson Prentice Hall, 2006. Print.

Project Objective.

A project objective is a concrete description of the specific, quantifiable amount of improvement planned above the baseline performance that was indicated in the problem statement.

The purpose of project objective is to clearly state the effect or change that the project is supposed to cause for the target group. One of the several techniques for writing an objective is to make sure that it is SMART - Specific, Measurable, Attainable/Achievable, Realistic, and Time-bound[3].

For the Wegmans project, it was very important to create a project objective. Developing a project objective would help determine the deliverables needed to achieve the objectives, which in turn, would help to identify risks and allow us to provide an estimate on costs, effort, and duration. Project objectives help to structure the project and validate success. The project objective for the Wegmans Project was:

> *Enhance the current Wegmans glass bottle to a new lightweight, hand,y and easy to pour plastic bottle in next two months. The project estimates that the new bottle design will be 15% more cube efficient, use 80% less material, and will reduce the transportation and handling costs by 30%. Also the new plastic bottle will be 30% more sustainable and will reduce product waste*.

Finalizing the project objective helps to understand the activities and resources that are required for the generation of the package that essentially helps to frame the scope of the project.

[3] Use project objectives to structure the project and validate success – Tech Republic. (n.d.). Retrieved February 07, 2016, from http://www.techrepublic.com/article/use-project-objectives-to-structure-the-project-and-validate-success/

The scope of the project was defined by using a tool termed, Project Scope, which is the next step.

Project Scope.

Project scope is nothing but documentation of what the boundaries of the project are. Project scope must be clearly communicated to all the team members, and everyone should be in agreement on how the project deliverables will be met.

The purpose of the project scope document is to clearly identify the in-scope and out-of-scope elements in order to clearly understand the area under consideration for the project. As a matter of fact, project objectives can be used for defining the project scope. In fact, from the Project Objective section, the deliverables addressing each project objective can help to identify the project scope[4]. For example, one of our project objectives was to reduce the amount of primary packaging material. By moving from glass to plastic less primary packaging would be utilized. Thus packaging material was considered in-scope of the project.

Project scope for Wegmans Barbeque Sauce. It is very vital to define the scope of the Wegmans barbecue sauce project and be as specific as possible in order to avoid scope creep[5], a situation where some parts of a project might end up requiring more work, time, or effort because of poor planning or miscommunication. After brainstorming the elements of the project, they were placed inside or outside of the project boundaries to show whether the element lies within the project scope or not. The results were then recorded in Table 1.[2]

---

[4] Project Scope Definition. (n.d.). Retrieved February 07, 2016, from http://www.tutorialspoint.com/management_concepts/project_scope_definition.htm

[5] Rouse, M., & Lebeaux, R. (n.d.). What is project scope? - Definition from WhatIs.com. Retrieved February 07, 2016, from http://searchcio.techtarget.com/definition/project-scope

Table 1.
In-scope and out-of scope elements for Wegmans Barbecue sauce

In-Scope	Out-of-Scope
1. Primary packaging • Material • Manufacturing process • Package Design (size, shape) • Graphics 2. Secondary packaging • Material 3. Sustainability (scorecard rating) 4. Transportation 5. End of Life Consideration	1. Tertiary packaging 2. Glass - Primary packaging material 3. Additional Vendor Qualification

Once the in-scope and out-of-scope elements are identified, and the deliverables are agreed upon, a project plan needs to be generated to achieve those deliverables. For example, by identifying sustainability as an in-scope element, we agreed that the package must be designed by taking the environment into consideration. Also by calling glass (primary packaging material) as an out-of-scope element, we confirmed that the primary packaging material should be lighter. Developing the project plan is the next step in the Define Phase.

Project Plan.

A Project Plan is a formal document that is used to guide and execute the project. It displays the project activities along the timeline. A Gantt chart is a simple scheduling tool that can be used to develop the project plan[2].

The purpose of the project plan is to define these activities that intend to deliver the output, while focusing on achieving customer's expectations in a timely manner. Once the list of activities has been created for the project, then responsibilities can be assigned for each activity. Next the timeline can be set for each task and sub-task.

It was very crucial to create a project plan for Wegmans project. Describing the tasks in the Gantt chart that need to be performed helped the project team to achieve the goals of the project efficiently and in a timely manner.

Table 2 shows the tasks/activities that are needed for successful project completion and Figure 1 shows the actual Gantt chart.

Once the project plan was approved, it was then time to summarize the project proposal to secure approval for the project goals and terms. Developing a project charter would help us achieve this. The project charter is the next and the last tool of the Define Phase for our project.

Table 2.

Tasks/Activities for Wegmans Barbecue Sauce

Task Name	Responsible for Completion	Start	End	Duration (days)
Market Research	Packaging Team + Industrial Team+Graphic Team	8/1/15	8/15/15	15
Retail Audit	Packaging Team + Industrial Team+Graphic Team	8/16/15	8/23/15	8
Current Product Analysis using SWOT	Packaging Team + Industrial Team+Graphic Team	8/16/15	8/27/15	12
Bottle Inspiration	Packaging Team + Industrial Team	8/28/15	9/8/15	12
Generate Various Bottle Designs	Packaging Team + Industrial Team	9/8/15	9/28/15	21
Evaluate Various bottle designs using Walmart Scorecard and sustainability matrix	Packaging Team	9/29/15	10/12/15	14
Finalize the bottle Design	Packaging Team + Industrial Team	10/13/15	10/15/15	3
Graphics Inspiration	Graphics Team	8/28/15	9/8/15	12
Generate Various Graphic Designs	Graphics Team+Packaging Team	9/8/15	9/28/15	21
Evaluate the graphics based on customer requirements	Graphics Team	9/29/15	10/12/15	14
Finalize the graphics for the bottle	Graphics Team+Packaging Team	10/16/15	10/26/15	11
Improved PET Bottle	Packaging Team + Industrial Team+Graphic Team	10/27/15	10/31/15	5
Secondary package Inspiration	Packaging Team	11/1/15	11/12/15	12
Create various secondary package designs	Packaging Team	11/13/15	11/22/15	10
Evaluate Various secondary package designs using Walmart Scorecard and sustainability matrix	Packaging Team	11/23/15	12/6/15	14
Finalize the secondary package design	Packaging Team	12/7/15	12/11/15	5
CAPE Analysis	Packaging Team	12/9/15	12/13/15	5
Build a prototype	Packaging Team + Industrial Team+Graphic Team	12/14/15	12/22/15	9
Present the Final Package Design	Packaging Team + Industrial Team+Graphic Team	12/23/15	1/4/16	13

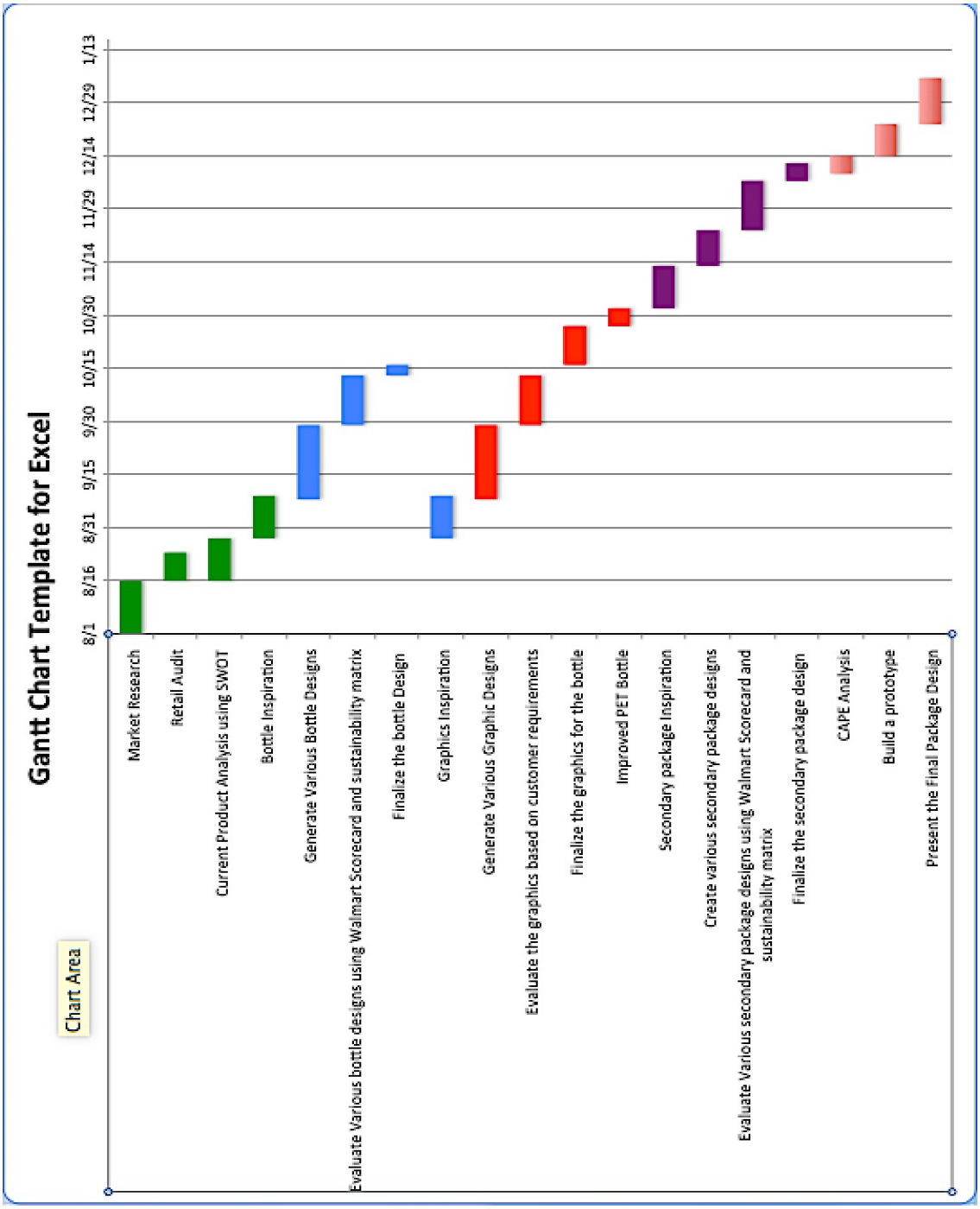


Figure 1: Gantt chart for Wegmans Barbecue Sauce

Project Charter.

A Project charter is a document that announces the beginning of the project with management support and is aligned with the organization objectives. It also helps in identifying the detailed project goals, roles and responsibilities, stakeholders, and timeline for the project, all of which will be referred throughout the project lifecycle.

The purpose of Project Charter is to[6]:

- Announce that a project has begun
- Authorize the project
- Demonstrate management support for the project and project manager
- Set management expectations for the results
- Spell out the nature and scope of the work
- Broadly define the project deliverables, schedule, and budget
- Align the project with organizational objectives

By applying the project charter tool to the Wegmans barbecue sauce project, detailed project goals, roles and responsibilities, stakeholders, and timeline for the project were identified. The project charter was referred throughout the lifecycle of the project. Also it helped to broadly define the project deliverables, schedule, and budget. (See Appendix 1 for the Project Charter.)

Once the project charter was completed, the next step was to determine that the goals and objectives of the DEFINE Phase are met, and then we could move to the Measure Phase. Tollgate review was the next tool that would help to identify this.

[6] Kloosterman, V. (2013). What is a Project Charter and why does your project need one? Retrieved February 12, 2016, from http://continuingprofessionaldevelopment.org/what-is-a-project-charter/

Define Phase Tollgate Review.

A tollgate review is a checkpoint in a DMADV project where the team members meet and determine whether or not the team has successfully completed the previous phase, and if they may pass the tollgate and move to the next phase. Tollgate reviews are carried out at the end of every phase in a DMADV project.

For the Wegmans barbecue sauce project, in order to ensure that the goals and objective for the Define Phase have been met, we conducted a Define Phase Tollgate Review. Conducting the DEFINE Phase tollgate review is very important in order to make the project successful.

The elements of a Define Phase tollgate review are: [2].

1. Develop the Business Case **Yes**/No
2. Perform SWOT Analysis **Yes**/No
3. Create the Opportunity Statement **Yes**/No
4. Project Objective Finalized **Yes**/No
5. Develop the Project Scope **Yes**/No
6. Project Plan (Gantt Chart) completed **Yes**/No
7. Finalize the Project Charter **Yes**/No
8. Tollgate Review Successful **Yes**/No

By successfully finishing the tollgate review, the DEFINE Phase is completed and the project moves into the Measure Phase.

Measure Phase

After successfully completing the Define Phase Tollgate Review, it is very important to understand the current state of the product. The Measure Phase allows us to gain an

understanding of the current state (i.e., the current supply chain) and customer requirements of the product. In this phase, the team focuses on data collection (based on customer's requirements) and converts them into Critical to Quality attributes (CTQs).

The purpose of the Measure Phase is to clearly understand the customer's requirements and develop the CTQs to address those requirements. This is achieved by dividing the market into different segments, and then developing CTQs for each segment[2]. For each CTQ identified, metrics and measurement systems are created. These would then help us to capture the performance of the Critical to Quality attributes (CTQs)

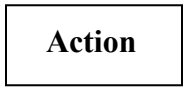
For the Wegmans barbecue sauce, it is very critical to understand the customer's requirement to build an efficient and sustainable package. First, it is very important to understand the current state of the product. Then it is very necessary to understand what the consumer wants? To understand the customer's requirements, a market survey was conducted. After understanding the customer's requirement, they were converted into measurable CTQs using the Quality Function Deployment tool.

This is a very important phase of the DMADV methodology, since it involves the identification of performance metrics for the components of the product and for the quality of the end result. For successful completion of the MEASURE Phase these following tools were used:

1. Process Flowchart
2. Market Survey (Market Research and retail audits)
3. Quality Function Deployment (House of Quality)

Process Flowchart.

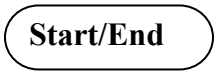
A flowchart is a picture of the separate steps of a process in sequential order. The following common symbols are used in flowcharting:



A rectangle represents an activity to be completed.

A diamond represents a decision to be made.

Input or Output



A terminator shape or a circle represents the beginning or end of a process.

An arrow indicates the process flow.

The purpose of flowchart is to visually document the sequence of activities in a process and to understand who is responsible for those activities. Also, a flowchart helps to

- Develop an understanding of how a process is done.
- Study a process for improvement.
- Communicate to others how a process is done.
- Identify when better communication is needed between people involved with the same process.
- Document a process.

In order to understand the package designing process for the Wegmans barbecue sauce, it was crucial to apply the flowchart tool. The application of flow diagram helped us to develop an

understanding of the package designing process; it also helped us to understand how the improvements could be made to the current barbecue sauce package.

Figure 2 presents the process flowchart for developing a package for the Wegmans barbecue sauce. [7].

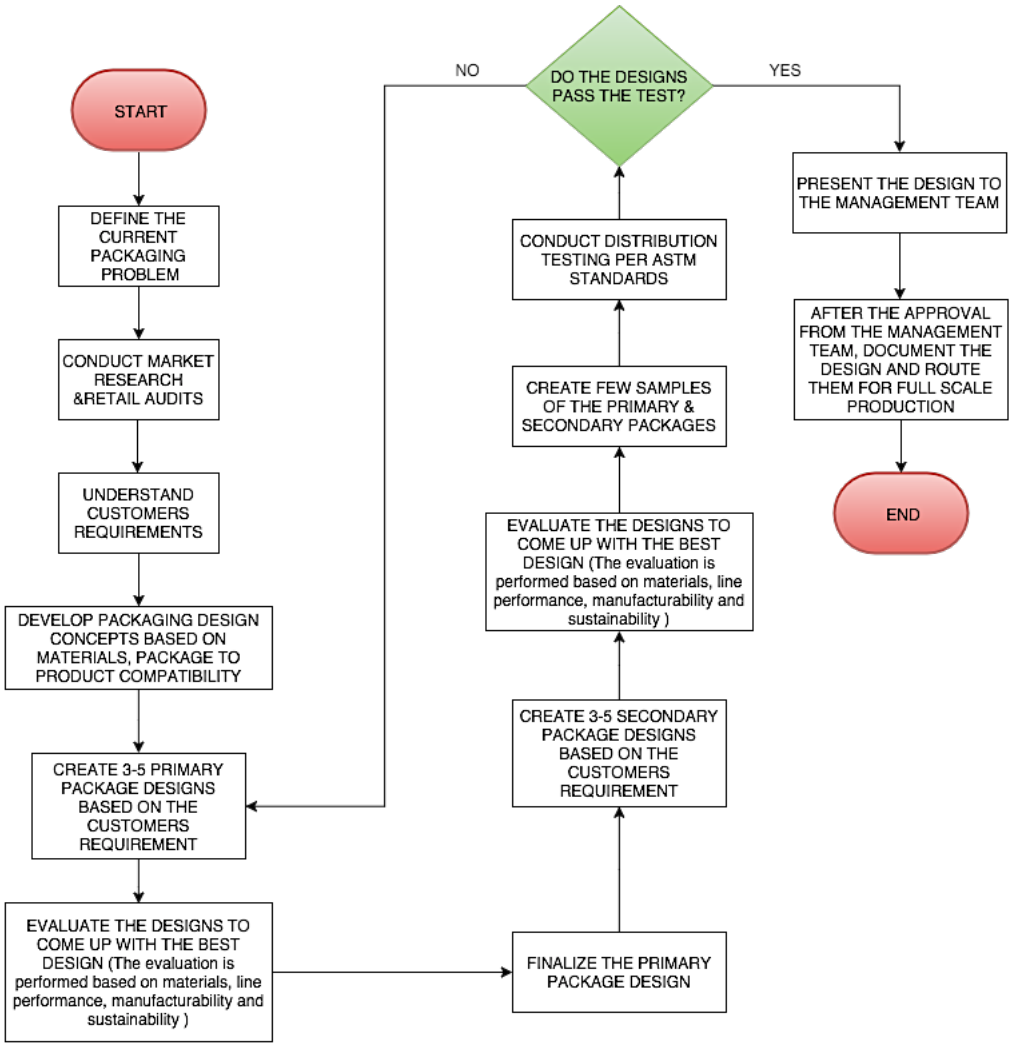


Figure 2: Process Flowchart for designing Wegmans Barbecue Sauce Package

[7] Draw.io - free flow chart maker and diagrams online. (n.d.). Retrieved February 15, 2016, from https://www.draw.io/

After developing the process, it was then important to understand the market and customer expectations. Conducting a market research and retail audit of the entire barbecue sauce category would help in understanding the growth and sales of the barbecue sauce category in the coming years. The market survey was the next tool used in the Measure Phase.

Market Survey.

A market survey is a tool used to gather information about existing or potential customers in a certain market or population. Researchers select a sample of customers from the population. The information from the survey is then used to assess attitudes and beliefs, and in turn, predict market behavior such as buying intentions.

The purpose of a market survey is to help us understand how the target customers behave and what it is that they want. Conducting a market survey gives us an idea to better promote or market a product to the target market.

By applying the market survey tool to the Wegmans barbecue sauce, we were in a better position to understand the current state of the barbecue sauce category and the preferences of the customers. It was also important to understand the market trends for a futuristic package design. By conducting market research, we were able to understand the future growth of the barbecue sauce category.

Market Research. Some of the key points of the market research that was conducted for the barbecue sauce category were: [8]:

- Innovative new products that make life easy for consumers while promoting attributes that they find important are pushing sales ahead.

[8]Kraushaar, A. (n.d.). Cooking Sauces, Marinades and Spices - US - December 2014. Retrieved February 15, 2016, from http://academic.mintel.com.ezproxy.rit.edu/display/679894/

- Older consumers (+65) are more concerned about their health, so they cut back on products that contain high levels of sodium and sugar.
- Boomers active in the BBQ sauce segment, but will likely change preferences to low sodium and sugar in upcoming years.
- Respondents report a somewhat likelihood to associate sauces and marinades with unhealthy attributes such as high sodium, sugar, calories, and artificial ingredients. Given that consumers are increasingly interested in healthy foods, brands that do not evolve alongside this shift are likely to lose sales

Market Performance. Cooking sauces experienced mostly flat sales between 2009 and 2014, and are expected to decline into 2019, when sales are projected to fall to less than $4 billion. Increasing consumer demand for fresh, healthy foods are hurting shelf-stable items such as cooking sauces.

The best- and worst-case forecasts take the value of cooking sauces, marinades, and spices from an estimated $9.6 billion in 2014 to $11.5 billion (best case) and $9.2 billion (worst case) in 2019. Based on the forecast derived above, however, Mintel expects these categories to grow to a total of $10.4 billion in 2019 (Kraushaar, n.d.).

Purchase Drivers. Current trends observed among customers and their shift towards healthy eating include these issues:

- Households being more likely to choose all natural and organic brands.
- Eliminating not-good-for-you ingredients
- Paying attention to no/low-allergen claims and third-party premium claims

Figure 3 shows the drivers that affect the purchasing decision of the consumer.

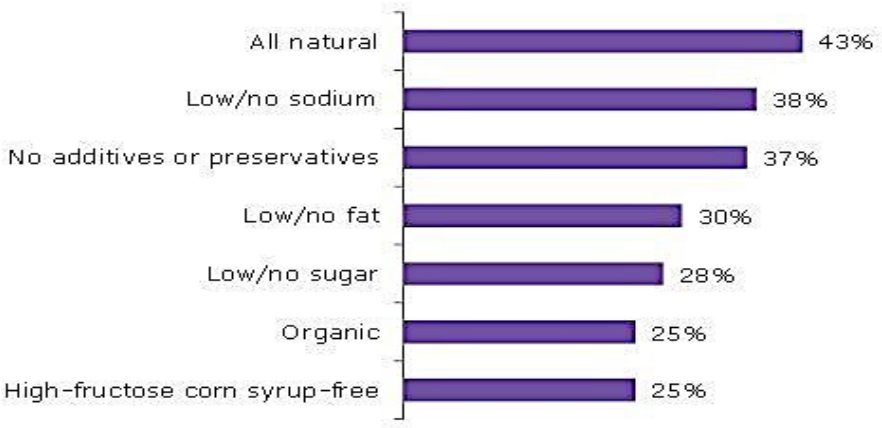


Figure 3: Graphical Representation of Purchase Drivers

*(All above research found in Mintel Database, December 2014. Mintel database does not include Wal-Mart sales information. Mintel does not have information on Wegmans specifically but rather all Private Labels together as one category).

Market Survey. After understanding the product and its market segmentation, it was then important to gain insights on the packaging aspect of the product. At first, it was necessary to understand what are the basic requirements that the customers expect from the package. Secondly, what are the requirements that the customers are able to articulate and are at the top of their minds when making choices and evaluating options? To understand this, a survey was conducted (based on age groups) to clearly understand the expectations of the end user. Table 3 shows the expectations of the users.

The survey was conducted based on age groups. The population was asked to evaluate the package based on categories that included materials, ease of use, cost, aesthetic appeal, shelf visibility, and sustainability. The customers were asked to rate each category on the scale of 1 to 5. Then all the ratings were averaged. The Total row is the sum of the average ratings from

different age groups observed in each category. The categories that received the highest rating are highlighted in yellow. Based on the highest rated categories, CTQs were designed.

Table 3.

Market Survey for Barbecue Sauce

Age Group	Material		Aesthtic Appeal	Easy to handle	Indoor v/s outdoor use	Cost v/s qty		Easy to pour	Graphic communication	Closure material	Product visibility	Recyclability
	Glass	Plastic			(Product portability)	Low	High		Healthy call outs			
18-30	3	3	5	3	5	5	1	3	5	1	5	5
31-60	1	5	3	5	3	5	1	5	5	1	5	5
60 - Onwards	5	5	1	5	1	5	1	5	5	3	3	5
Total	9	13	9	13	9	15	3	13	15	5	13	15

The key learning from this survey is that the customers/end users want their bottle to be lightweight, easy to handle, and recyclable. The product must be easy to dispose of, contain health information, and be inexpensive as compared to the competitors. These customer expectations were then converted into critical to quality (CTQ) attributes. House of quality is the next tool that would help in developing the CTQs.

Quality Function Deployment: House of Quality.

After receiving the feedback from the surveys, customer requirements were converted into CTQs with the help of Quality Function Deployment (QFD). In this QFD tool, a house of quality is generated. House of quality is a house that captures the “voice of the customer”, or customer requirements, then translates them into products or services that meet the customer’s requirements. It helps in summarizing important information in one or more charts.

The purpose of using the House of Quality tool is to[9]:

- Improve communication and sharing of information within a cross-functional team charged with developing a new product.
- Identify the gaps or "loopholes" in the current package design.
- Capture and display a wide variety of important design information in one place in a compact form.
- Support understanding, consensus, and decision making, especially when complex relationships and trade-offs are involved.

The main "bottom line" benefits of using the House of Quality tool are:

- Greater likelihood of product success in the marketplace, due to the precise targeting of key customer requirements
- Reduced overall design cycle time, mainly due to a reduction in time-consuming design changes. This is a powerful benefit. Customer requirements are less likely to have changed since the beginning of the design project; more frequent design cycles mean that products can be improved more rapidly than the competition.
- Reduced overall cost due to reducing design changes, which are not only time-consuming, but are very costly, especially those that occur at a late stage.
- Reduced product cost by eliminating redundant features and over-design.

By applying this tool to the Wegmans barbecue sauce package, we were able to convert the customer requirements into tangible CTQ attributes. This would help us to identify the issues

[9] Quality Function Deployment (QFD). (n.d.). Retrieved February 17, 2016, from http://www.dhutton.com/samples/sampqfd.html

with the current barbecue sauce package, and reduce the time and cost due to last-minute design changes and by over-designing the package.

House of Quality tool for Wegmans Barbecue Sauce Package. After receiving the feedback from the surveys, consumer requirements were converted into CTQs, with the help of Quality function Deployment. These CTQs are the key attributes for manufacturing the final product. The house is divided into sections, viz. Left Side, Ceiling, Roof, Competitive Section, and Foundation. The sections and their contents are: [10]:

Left Side - the customer requirements

Ceiling – the design features and technical requirements

Roof – a matrix describing the relationship between the design features

Competitive Section – your product rating in comparison with the market competitors

Foundation – Benchmarking and target values used to rank the Design Features or functional requirements. Based on the "relative weight" score for each functional requirement we will have to design the final product.

The customer's requirements are shown on the left side of the house, functional requirements on the ceiling, and competitors' ratings on the right, and relative weights at the bottom. Also, the picture includes a legend to help understand what each symbol means.

While designing the House of Quality for the barbecue sauce package, we needed to take into consideration the consumer (i.e., the end user), as well as the customer (e.g., the retailer). The House of Quality that is generated (see Appendix 2) takes into account the consumer, as well as the customer. The functional requirements were designed accordingly.

[10] Quality Function Deployment (QFD) and House of Quality (HOQ). (n.d.). Retrieved February 17, 2016, from http://www.sixsigmastudyguide.com/house-of-quality-hoq/

The process of developing a House of Quality for the Wegmans package is explained below. House of Quality for Wegmans barbecue sauce consists of six rooms. Figures 4 -12 provide a detailed explanation for each room, the interaction between the customer requirements, and resulting important ratings for the Wegmans barbecue sauce package.

Customer Requirements (WHATS) Room: This room starts with a list of objectives, or the WHATs, that we wanted to accomplish. In the context of developing a new package, this is a list of customer requirements, which is often called the Voice of the Customer (VOC). The items contained in this list are usually very general and difficult to implement directly; they require further detailed definition.

For the Wegmans project, this room helped us to identify the customer needs for the package. (See Figure 4.)

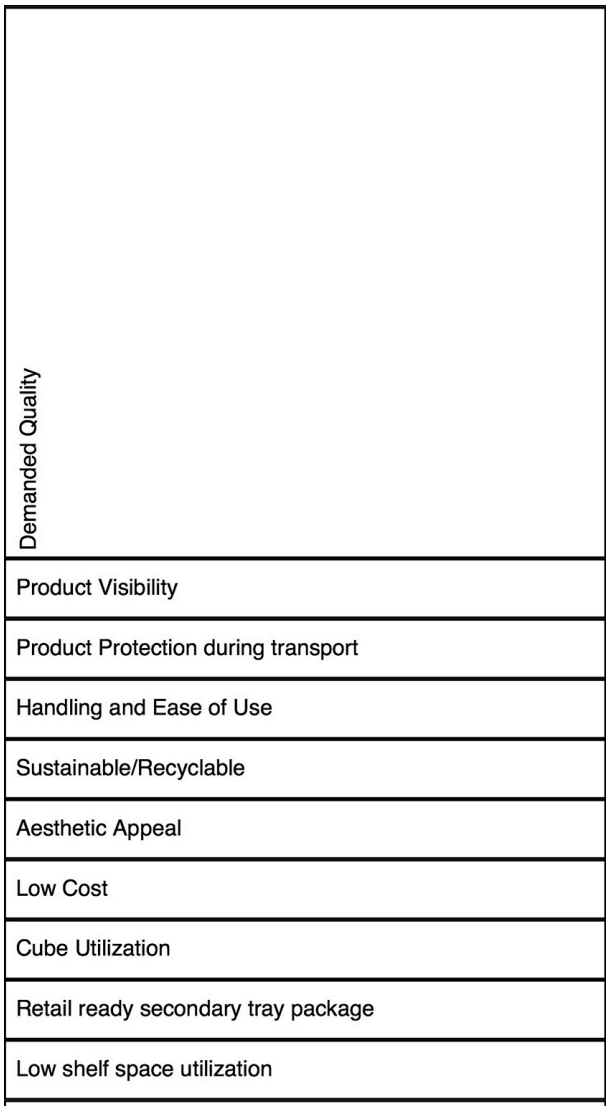


Figure 4: Customer requirements room for Wegmans barbecue sauce

As shown in Figure 4, product visibility, low cost, cube utilization are some of the customer requirements. Although these requirements are desirable, they are not actionable. These need to be converted into functional requirements (i.e., How are we going to satisfy the WHAT's?). For every WHAT that has been described, there could be one or multiple HOWs.

Functional Requirements Room (the Ceiling): This room is also know as the HOWs room. In this activity, the team tries to answer the question: How would we measure package performance that would provide us an indication of customer satisfaction for a specific "What"? The team came up with at least one performance measure, but sometimes it could take several measures to adequately characterize package performance.

For the Wegmans project, it was very important to develop the functional requirements in order to cater to customer requirements. Figure 5 shows the functional requirements that were critical for the Wegmans Barbecue sauce.

Figure 5: Functional Requirements Room for Wegmans barbecue sauce

As shown in Figure 5, the customer requirements were measured against the functional requirements, such as packaging material, tamper evidence feature, and sustainability metrics. Once the functional requirement room was completed, the team began to find a relation between all Customer Requirements and Functional Requirements in the Relationship Matrix room. This led us to the next room, the Relationship Matrix room.

Relationship Matrix Room: In this room, the relationship between all Customer Requirements and Functional Requirements are developed. During this activity, the team looked for a relationship a specific HOW and a specific WHAT. Is there cause and effect between the two? Based on the group decision, the team assigned a strong, medium, weak ,or no relationship value to this specific WHAT/HOW pairing. Then the team went on to the next WHAT/HOW pairing. This process continued until all the WHAT/HOW pairings were reviewed[11].

For the Wegmans barbecue sauce package, it was very crucial to identify the relationships between the Customer requirements and Functional requirements. Figure 6 shows the room where a relationship has been developed between each single Customer requirement and every Functional Requirement. For example, there would be strong relation between Product Protection and Packaging Material. This is because, if the quality of packaging material is good, then it will definitely protect the product.

Demanded Quality	Packaging Material	Package Weight	Tamper Evidence	Cube Efficiency	Cost	Sustainability metrics	Pallet Stability	Design Features
Product Visibility	○				▲			▲
Product Protection during transport	⊖	▲	⊖		⊖	⊖	○	○
Handling and Ease of Use	⊖	⊖			▲			⊖
Sustainable/Recyclable	⊖	⊖	▲	⊖	⊖	⊖	○	⊖
Aesthetic Appeal	⊖				○			○
Low Cost	⊖	○		○	⊖			⊖
Cube Utilization	▲			⊖	○	⊖	⊖	⊖
Retail ready secondary tray package	⊖	⊖		⊖	⊖	⊖	⊖	⊖
Low shelf space utilization				○	○			⊖

Figure 6: Relationship Matrix Room for Wegmans barbecue sauce

[11] Jenney, J. (n.d.). The Manager's Guide. Retrieved February 17, 2016, from http://themanagersguide.blogspot.com/2011/05/constructing-basic-house-of-quality.html

Figure 7 shows the symbols that are commonly used to show strength of the relationships between the Customer Requirements and Functional Requirements

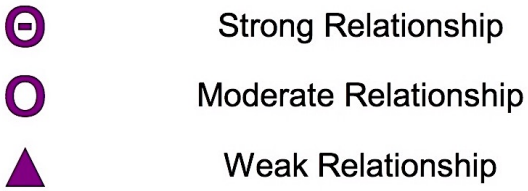


Figure 7: Legend for Relationship Matrix

Correlation Matrix Room (the ROOF): The correlation matrix is a triangular table attached to the Functional Requirements that helps in establishing a correlation between each Functional Requirement. Positive correlations are those in which one HOW supports another HOW. Negative correlations are those in which one HOW adversely affects the achievement of another HOW. Please note it is also important to show the direction of improvement for every Functional Requirement to bring more clarity to the correlation matrix.

For the Wegmans package, it was very important to use this room in order to understand the relation between each individual Functional Requirement. Please refer to Figure 8 that shows the correlation between each individual Functional Requirements. Figure 9 shows the symbols that are used to show the strength of correlation between the HOWs. If there is no correlation, the field is left blank.

As shown in Figure 8, it is difficult to create a correlation between Packaging Material and Package Weight. This is because a good quality packaging material could be heavy or could be light. There is no fixed relation between the material and weight. Since no correlation exists,

that field is left blank. Another example would be a strong negative correlation between Package Weight and Pallet Stability. As package weight increases, the pallet stability decreases.

After completing the four rooms and getting an idea of the package, it was then time to understand our competitors. The Competitive Assessment Room is the next room in the House of Quality.

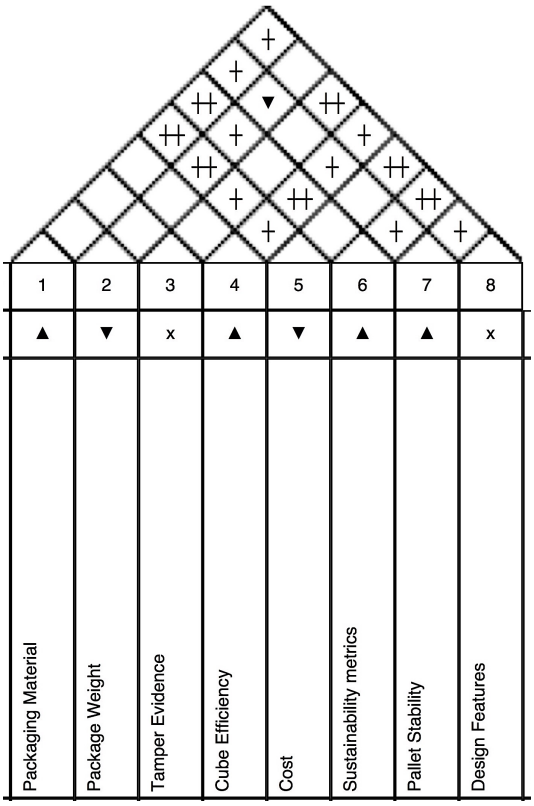


Figure 8: Correlation matrix room for Wegmans barbecue sauce

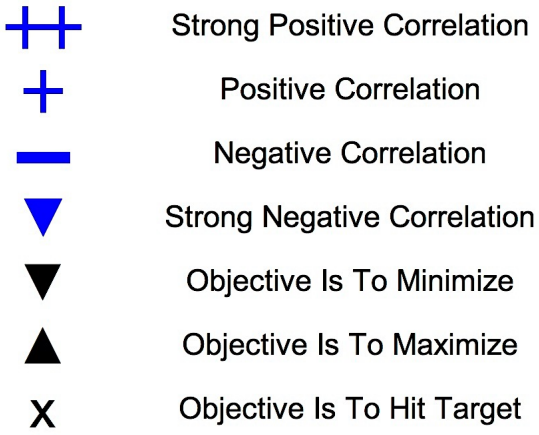


Figure 9: Legend for Correlation matrix

Competitive Assessment Room: The Competitive Assessment is a graphical representation of how the current package performs with respect to its competitors. The packages are rated on a scale from 1 to 5 (1- least desirable, 5 –most desirable) against the WHATs. It is extremely important to understand the customer's perception of a package, relative to its competition.

Conducting a competitive assessment for the barbecue sauce was crucial to understand the perception of our customer with respect to its competitors. Figure 10 shows the competitive assessment room for the Wegmans barbecue sauce. Four competitors were taken into consideration. The current Wegmans package and the competitor’s packages were evaluated on the customer’s requirements.

									Wegmans	Competitor 1	Competitor 2	Competitor 3	Competitor 4
Product Visibility	O				▲			▲	3	4	3	4	4
Product Protection during transport	Θ	▲	Θ		Θ	Θ	O	O	4	5	4	4	5
Handling and Ease of Use	Θ	Θ			▲			Θ	3	5	3	3	5
Sustainable/Recyclable	Θ	Θ	▲	Θ	Θ	Θ	O	Θ	3	5	3	5	5
Aesthetic Appeal	Θ				O			O	2	4	2	4	4
Low Cost	Θ	O		O	Θ			Θ	4	5	2	5	3
Cube Utilization	▲			Θ	O	Θ	Θ	Θ	1	5	2	3	4
Retail ready secondary tray package	Θ	Θ		Θ	Θ	Θ	Θ	Θ	1	1	1	1	1
Low shelf space utilization				O	O			Θ	1	4	1	3	3

Note: Primary Packaging material for Wegmans – Glass, Competitor 1- Plastic, Competitor 2- Glass, Competitor 3- Plastic, Competitor 4- Plastic.

Figure 10: Competitive Analysis room for Wegmans barbecue sauce

For example, when considering Product Protection during transportation, the Wegmans bottle scored low, as opposed to its plastic competitors. This is because glass could break easily during transportation and plastic cannot. On the similar analogy, the rest of the room was completed.

Importance Ratings: Importance ratings are useful for prioritizing efforts and making trade-off decisions. Importance ratings are divided into two categories: WHAT Importance ratings and HOW Importance ratings.

WHAT Importance Rating. The WHAT Importance Rating is a rating based on customer assessment. It is expressed as a relative scale (typically 1-5), with the higher numbers indicating greater importance to the customer. The WHAT importance ratings are listed in a column on the

left side of the WHATs. Since we can only act from the HOWs, importance ratings for these HOWs are needed.

For the Wegmans project; it was necessary to rate the customer requirements (WHATs) in order to gain better understanding of the customer preferences. Please refer to Figure 11 below.

From Figure 11, it is clear that the customers prefer that their product be protected during transportation and have low cost, as opposed to being visible through the package and be aesthetically appealing. Let us now calculate the HOW importance rating.

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality
1	3	7.9%	3	Product Visibility
2	9	13.2%	5	Product Protection during transport
3	9	10.5%	4	Handling and Ease of Use
4	9	13.2%	5	Sustainable/Recyclable
5	9	7.9%	3	Aesthetic Appeal
6	9	13.2%	5	Low Cost
7	9	13.2%	5	Cube Utilization
8	9	10.5%	4	Retail ready secondary tray package
9	9	10.5%	4	Low shelf space utilization

Figure 11: WHAT importance rating for Wegmans barbecue sauce

HOW Importance Rating: The Importance Rating for the HOWs provides a relative importance of each HOW in achieving the collective WHATs. In order to calculate the HOW, importance-rating weights are assigned to the RELATIONSHIP symbols as 9-3-1 weighting shown in Figure 12.

For the Wegmans project, it is very important to calculate this rating. This will help us is designing the final package to meet our customer's requirement. For each column (or HOW), the

WHAT importance value is multiplied by the symbol weight, producing a value for each relationship. Summing these values vertically defines the HOW importance value. In Figure 12, the HOW importance rating for the first column is calculated in the following manner. The dot in circle symbol weight (9) is multiplied by the corresponding WHAT relative weight value (7.9), forming a RELATIONSHIP value of 71.1. Further, all the relationship values are calculated accordingly. Then all the values in the HOW column are added attributing to a final HOW importance rating of 652.6. This process is repeated for each column, as shown in Figure 12.

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality	Packaging Material	Package Weight	Tamper Evidence	Cube Efficiency	Cost	Sustainability metrics	Pallet Stability	Design Features
1	3	7.9%	3	Product Visibility	O				▲			▲
2	9	13.2%	5	Product Protection during transport	Θ	▲	Θ		Θ	Θ	O	O
3	9	10.5%	4	Handling and Ease of Use	Θ	Θ			▲			Θ
4	9	13.2%	5	Sustainable/Recyclable	Θ	Θ	▲	Θ	Θ	Θ	O	Θ
5	9	7.9%	3	Aesthetic Appeal	Θ				O			O
6	9	13.2%	5	Low Cost	Θ	O		O	Θ			Θ
7	9	13.2%	5	Cube Utilization	▲			Θ	O	Θ	Θ	Θ
8	9	10.5%	4	Retail ready secondary tray package	Θ	Θ		Θ	Θ	Θ	Θ	Θ
9	9	10.5%	4	Low shelf space utilization				O	O			Θ
				Target or Limit Value	none	none	none	none	none	none	none	none
				Difficulty								
				Max Relationship Value in Column	9	9	9	9	9	9	9	9
				Weight / Importance	652.6	360.5	131.6	402.6	563.2	450	292.1	710.5
				Relative Weight	18.3%	10.1%	3.7%	11.3%	15.8%	12.6%	8.2%	19.9%

Figure 12: HOW Importance rating for Wegmans barbecue sauce

Based on the importance ratings, the team can identify where the package needs to be improved to beat the competition.

Developing all the individual rooms and then putting them together completes the house of quality. Please refer to Appendix 2 for the complete House of Quality for Wegmans barbecue sauce.

Once the House of Quality is developed, the next step is to determine that the goals and objectives of the Measure Phase have been met, then we can move to the Analyze Phase. The tollgate review is the next tool that helped to identify this.

Measure Phase Tollgate Review.

A tollgate review is a checkpoint in a DMADV project where the team members meet and determine whether the team has successfully completed the previous phase or not, and decide if they may pass the tollgate and move to the next phase. Tollgate reviews are carried out at the end of every phase in the DMADV project.

The purpose of the tool gate review is to make sure that the goals and objective of that specific phase have been met and that the team is ready to move to the next phase.

For the Wegmans barbecue sauce project, in order to ensure that the goals and objective for the Measure Phase have been met, we will be conducting a Measure Phase Tollgate Review for the Wegmans barbecue sauce project. Conducting the Measure Phase tollgate review is very important in order to make sure that the CTQs have been identified clearly to address the customer requirements.

The elements of a Measure Phase tollgate review are as follows[2].

1. Develop the Process Flowchart **Yes**/No
2. Conduct Market Segmentation (Market research / Retail Audits **Yes**/No

3. Create Market Survey to develop Customer Requirements **Yes**/No
4. Convert Customer Requirements into CTQs using HOQ tool **Yes**/No
5. Pass the MEASURE Phase Tollgate Review **Yes**/No

By successfully finishing the tollgate review, the Measure Phase is completed and the project moves into the Analyze Phase.

Analyze Phase

This is the third phase of the DMADV methodology. In this phase, the best design concept were developed that will address the voice of the customer/ customer demands (CTQ).

The purpose of Analyze Phase is to[2]

- Generate alternative design concepts for each CTQ
- Evaluate the alternative design concepts for each CTQ using a Pugh Matrix.
- Combine the best parts of the design concepts (if necessary) to create a final design.

In order to finalize the design concept for the Wegmans barbecue sauce, it is very critical to implement the Analyze Phase. By implementing the Analyze phase, several alternatives will be evaluated, and the most effective alternative, based on the best parts of the best concepts, were selected for final package design.

This is an equally important phase of the DMADV methodology since it involves developing the final design for barbecue sauce package. For successful completion of the Analyze Phase the following tools were used:

- Benchmarking
- Pugh Matrix
- Wal-Mart Scorecard
- CAPE Analysis

Benchmarking.

Benchmarking is the process of measuring products, services, and processes against those of organizations known to be leaders in the market. It counteracts the “reinvent the wheel” syndrome[2].

The purpose of Benchmarking is to help identify the areas or processes for improvements - either continuous improvements or dramatic improvements. It is used to come up with innovative solutions to the problems faced by the company for its current product(s).

Applying the Benchmarking tool to our Wegmans barbecue sauce helped us in comparing where we stand with respect to our competitors and learn what can we do to improve our packaging. With this tool, we compared the current competitor designs and studied them in detail. If some attributes of the competitor's design makes sense, we can come up with an alternative design concept to package our product.

Benchmarking for Wegmans barbecue sauce. We benchmarked with six different competitor’s packages. The goal was to understand the different packaging concepts used by our competitors. The following competitor products were used for Benchmarking:

Kraft	Sweet baby rays
KC Masterpiece	Dinosaur BBQ
Uncle ralphs	Jack Daniels

From the products observed in the market, it was found that:

- 3/6 competitors are still using glass as a primary package.

- 4/6 competitors have now moved from glass to plastic, PETE bottle (Kraft, KC Masterpiece).
- The products in PETE bottles have high cube efficiency and low package-to-product ratio
- 1/6 bottle had a tamper-evident feature.
- More bottles fit on the pallet and on the shelf.
- The PETE bottles are more cubicle, as opposed to cylindrical glass bottles.
- None of the competitor's bottles had a retail-ready secondary tray.
- 1/6 bottle had an orifice reducer that facilitates controlled dispensing of the BBQ sauce.

After using the Benchmarking tool, it was found that there was much improvement for our current BBQ sauce bottle. For example:

1. Moving from Glass to PET as a primary packaging material. This would save on transportation costs.
2. Introducing orifice reducer to have a controlled flow of the barbecue sauce. This would reduce product waste.
3. Making the bottle more cubicle instead of cylindrical. This would improve the cube efficiency, as well as reduce the space required on shelves.

Let us now evaluate those competitors (concepts) using a PUGH matrix to get a better idea of the advantages of incorporating some of their design features into our barbecue sauce package. PUGH matrix is the next tool that was used in the ANALYZE Phase. By using this tool, we could redesign our primary package to make our product stand out on the shelves and boost our sales.

PUGH Matrix.

The Pugh Matrix (also known as decision matrix and was developed by a professor named Stuart Pugh) is a decision-making model that helps to choose the best concept between the lists of alternatives.

The purpose of the Pugh Matrix is to provide the team with a holistic view of needs v/s different alternatives in the form of a matrix, instead of listing down the positives and negatives of each option. This is an effective tool since it reduces the time taken by the team to analyze the scores, as compared to deploying the wrong solution to a project.

The Pugh matrix looks like the one as shown in Table 4 below. The table consists of a Criteria column (based on the CTQs identified), which are really important. Then it has a baseline column against which we will be comparing the alternative design concepts for each criterion. It also has different columns for different alternatives.

Table 4.

A Standard PUGH Matrix

Design Criteria	Baseline	A	B	C	D
1					
2					
3					
4					
Sum of '+'s					
Sum of '-'s					
Sum of '0's					
Total					

The columns A, B, C, D relating to the design criteria are assigned a '+' or a '0' or a '-' ranking with respect to the baseline design concept. A '+' ranking means that the alternative design concept is superior to the baseline design concept in reference to the design criteria. A '0' means that it is similar and a '-' indicates that the alternative concept is inferior to the baseline design concept. The next step is to evaluate the alternative design concepts based on the scores. The concept that has the highest total score wins.

By applying the Pugh matrix to Wegmans barbecue sauce; we were able to understand the negatives of our design (baseline) with respect to the alternative concepts. There could be a

possibility of an excellent design feature that is used in an alternative concept, but may not be the wining design. However, it could be utilized in the best design to make it more efficient.

Table 5 shows the application of Pugh matrix to the Wegmans barbecue sauce. Five alternative primary package designs were analyzed via a Pugh Matrix with the current BBQ sauce glass bottle serving as a baseline. The criteria chosen was based off the CTQs identified using the House of Quality tool. Please take a look at the Pugh Matrix below for more information.

Table 5.

PUGH Matrix for Barbecue Sauce Bottle

Design Criteria	Baseline (Wegmans current BBQ sauce glass bottle)	Concept 1 (PETE)	Concept 2 (Glass)	Concept 3 (PETE)	Concept 4 (PETE)	Concept 5 (Glass)
Primary Package Weight	0	+	0	+	+	0
Primary Package material	0	+	0	+	+	0
Label Material	0	0	0	0	0	0
Tamper Evidence	0	+	0	0	0	0

Primary Package Cube Efficiency	0	+	+	+	+	+
In Use and Storage	0	+	0	+	+	0
Secondary package	0	+	0	+	+	0
Low Environmental Impact (Sustainable)	0	+	0	+	+	0
Controlled Dispensing	0	0	0	0	+	0
Cost of package	0	-	0	-	-	0
Sum of '+'s	0	7	1	6	7	1
Sum of '-'s	0	1	0	1	1	0
Sum of '0's	0	0	0	0	0	0
Total	**0**	**6**	**1**	**5**	**6**	**1**

The description below explains how this tool was used for Wegmans barbecue sauce. First, the design criteria were selected from the CTQs identified from *House of Quality*. The

current Wegmans glass bottle was considered as a baseline, and five alternative concepts were compared against that baseline. From the Benchmarking tool, it was observed that most of the competitors were using PET as a primary package material. It was decided to consider PET while designing alternative packages. Let us now compare each alternative design to our base for each criterion.

Primary Package Weight & Primary Package Material: PET is a transparent material similar to glass, but is light in weight. So the concepts that utilized PET as a primary packaging material were considered superior, as compared to the baseline that used glass as a primary packaging material.

Label Material: All the bottles used pressure sensitive paper label similar to the baseline. So all of them were assigned a weight of '0' since it has no effect.

Tamper Evidence: During Benchmarking, it was observed that only 1/6 bottle incorporated the tamper evidence feature. It looked like the feature was not popular. But since it was used by one of our competitor, we decided to create a concept that will have a tamper-evident feature. For concept 1, tamper evidence feature was added. So concept 1 was given a superior ranking (+) for that criterion.

Primary Package Cube Efficiency: All the alternative bottle designs were made more cubicle to improve the cube efficiency, as compared to the baseline. Hence all the alternative concepts have a '+' ranking.

In Use and Storage: Since glass is rigid and breakable, concepts 2 and 5 were treated similar to the baseline i.e. '0' and concepts 1,3&4 were treated superior since PET is not breakable during normal household handling. Hence concepts with PET as a primary packaging material were assigned a ranking of '+'.

Secondary package: Since glass is heavy, the secondary packaging needs to be a RSC corrugated paperboard with higher ECT/BCT strengths. PET is light in weight and can have lower ECT/BCT values. So a lighter paperboard material can also be used. Also, there is a possibility of using PP shrink-wrap, which is advantageous over corrugated paperboard. Hence the concepts with PET are given a superior rating, as opposed to glass.

Low Environmental Impact (Sustainable): Although it is true that Glass and PET are both recyclable, the recycling rates are different. PET is more recycled than glass. Also PET is more sustainable, as opposed to glass, because it costs less to transport PET bottles as opposed to glass bottles[12].

Controlled Dispensing: During Benchmarking, it was observed that 1/6-competitor concepts used an orifice reducer. This is an advantageous feature since it will allow us to have a controlled flow of the barbecue sauce. This was incorporated in Concept 4. So concept 4 was given a superior ranking (+) for that criterion.

Cost of package: From Benchmarking, it was observed that sauces that were in PET bottles were expensive, as opposed to that in Glass bottles. Hence they have been assigned a'-' ranking.

From Table 5, it is very clear that we were able to reduce the number of design concepts. However, we have a tie situation. We have two best designs, i.e. concept 1 and concept 4. In order to come up with a final design, we need to evaluate these two designs with respect to the current package. For this purpose, Wal-Mart scorecard and CAPE analysis tool were used. These two tools helped us in coming up with the final package. The next step in the Analyze Phase is finalizing the best design.

[12] Sustainability. (n.d.). Retrieved February 21, 2016, from http://www.petresin.org/sustainability.asp

Wal-Mart Scorecard.

Wal-Mart's packaging scorecard is an evaluation tool that allows the packaging engineers to evaluate a concept relative to the baseline concept based on specific metrics. The Wal-Mart scorecard software uses the following metrics for evaluating the packages:

- Carbon footprint CO2 per ton of Production
- Sustainable Material
- Package/ Product Ratio
- Cube Utilization
- Recovery

Let us understand the impact of each and every Metric on the package. Please see below for the definition of the metric and how it impacts the overall scorecard.

Carbon Footprint. A carbon footprint is historically defined as "the total set of greenhouse gas emissions caused by an individual, event, organization, product and is expressed as CO_2[13]. The purpose of this metric is making the designer aware of the environmental impacts that the designed package is making. This metric is the output from the Wal-Mart scorecard. The scorecard calculates it, and ideally the score should be low.

Sustainable Materials. Sustainable materials are materials used throughout our consumer and industrial economy that can be produced in required volumes without depleting non-renewable resources and without disrupting the established steady-state equilibrium of the environment and key natural resource systems[14]. This metric is the output from the Wal-Mart

[13] (n.d.). Retrieved February 23, 2016, from https://en.wikipedia.org/wiki/Carbon_footprint

[14] Sustainability. (n.d.). Retrieved February 21, 2016, from http://www.petresin.org/sustainability.asp

scorecard. The scorecard calculates it, and ideally the score should be high. This would mean that the package uses more sustainable material.

Package-to-product ratio. It is defined as ratio of the weight of package to the weight of the product. The purpose of this metric is to understand the amount of material that is used to transport the product. Ideally this ratio should be as low as possible. This metric is the output from the Wal-Mart scorecard. This means that the product is being transported by using a lesser amount of packaging material, thereby supporting sustainability

Cube utilization. Cube utilization refers to efficient use of space within the primary package, secondary package and trailer. Cube efficiency is made up of two components, i.e. Selling Unit Cube Utilization (SUCU) and Transport Cube Utilization (TCU). The purpose of calculating SUCU and TCU is to make sure that the package we are designing makes the maximum use of space. In short, we are shipping less air during distribution of the product. SUCU is the ratio of product volume to selling unit volume. TCU is ratio of Volume of total selling unit packaging by volume of transport unit packaging (mostly pallets). This metric is an input to the Wal-Mart scorecard software, but is also reflected as an output when the final scores are out. This input helps the software to calculate the transportation metrics and aids in the final Weighted Average score.

Recovery. This metric is defined as the amount of materials that can be recovered from the package. The purpose is to maximize the recovery score. This metric is the output from the Wal-Mart scorecard.

By applying Wal-Mart scorecard to Wegmans barbecue sauce, we were able to evaluate the alternative design concepts and finalize a package design. From the PUGH matrix, two best designs were identified, i.e. Concept 1 and Concept 4.These two best designs needed to be

evaluated in detail, based on the scorecard metrics to come up with a final package design. Please refer to Appendix 3 for a detail exercise.

From the calculations shown in Appendix 3, it is very clear that concept 4 has the highest score per Wal-Mart scorecard. This is the best design. It is more cube efficient and sustainable, and has a lesser carbon footprint. Hence we will be pursuing this option for our primary package. Wal-Mart scorecard has helped us to come up with a best package design for our barbecue sauce product. Please take a look below for the detailed specifications of the finalized PETE bottle along with a graphical representation.

Proposed Bottle Specifications:

Bottle

Material: PETE, clear

Dimensions (in): 7.8750 x 3.3 x 1.8950

Closure

Material: Continuous threaded Polypropylene, black matte

Orifice Reducer

Material: LDPE, natural

Label

Material: Paper, pressure sensitive

Labels: Front, back, wrap around closure for tamper evidence

Packaging Process

Volumetric Filling

After finalizing the design with the Wal-Mart scorecard, it is now necessary to understand the transportation savings and how this new package design will help the retailer to optimize the shelf storage. Using the next tool, called the CAPE analysis, does this.

CAPE Analysis

CAPE Analysis is conducted by using palletization software called CAPE developed by ESKO. This software helps to determine the pallet pattern and pallet load. It also provides information on the weight of the entire pallet and helps to optimize the truckload.

The purpose of CAPE software to help optimize the truck load so that we can distribute maximum product in the same container and reduce our fuel consumption. This has a direct impact on the Sustainability score of the package. If the package is cube efficient, a bigger number of products can be shipped to the retailer.

The case dimensions and weight are inputs to the CAPE software. From the inputs provided, the CAPE software develops number of pallet patterns. It is then up to the discretion of the company which pallet pattern do they want to follow. Typically it is seen in the packaging industry that many of the companies follow an interlocking pallet pattern. This is because it provides more stability to the pallet and hence there is a less chance of product damage.

By conducting the CAPE analysis for the barbecue sauce, we were able to understand the advantages of the new package design. The report generated by this software would quantitatively show the difference between the older and the newer Wegmans package.

CAPE Analysis for Wegmans: In this section, a CAPE analysis was performed on the older and newer package to show the advantages of the newer packaging design (Concept 4). The calculations are documented in Appendix 4. Please review Appendix 4 for more details.

From Appendix 4, it is very clear that the new package design (Concept 4) is very efficient and sustainable in terms of distribution. Please see Table 6 below for a side-to-side comparison.

Table 6.

Direct Comparison of the Wegmans Glass Bottle and PET (Concept 4) Bottle

	Wegmans Glass Bottle	Concept 4
Bottles/Case	12	12
Case/Layer	14	22
Layer/Load	6	5
Case/Load	84	110
Bottles/Load	1008	1320
Pallets/Truck	44	48
Bottles/Truck	44352	63360 (43% more)

From Table 6, it is clear that we are able to ship 43% more product in the same 53" footer truck. This means that the fuel costs will be significantly reduced. To get an idea of the larger picture, please see the calculations given below.

Calculations:

Current glass bottle = 44,352 bottles/truck, 1,000,000 bottles/44,352 bottles/truck = 23 trucks

Proposed Concept 4 PET bottle = 66,360 bottles/truck, 1,000,000 bottles/66,360 bottles/truck = 16 trucks

For every 1million bottles shipped, our new bottle needs 7 less trucks. This means there is a 31% reduction in CO2 emissions from truck optimization.

Once the Wal-Mart Scorecard evaluation and CAPE analysis was performed, the design was then finalized and ready to be prototyped for distribution testing. By performing a Tollgate review, it was easy to determine whether the goals and objectives of the Analyze Phase had been met and that we could successfully move to the Design Phase. Tollgate review is the next tool that helped to identify this.

Analyze Phase Tollgate Review.

A tollgate review is a checkpoint in a DMADV project where the team members meet and determine whether the team has successfully completed the previous phase or not and decide if they may pass the tollgate and move to the next phase. Tollgate reviews are carried out at the end of every phase in the DMADV project.

The purpose of the tollgate review is to make sure that the goals and objective of that specific phase have been met and the team is ready to move to the next phase.

For the Wegmans barbecue sauce project, in order to ensure that the goals and objective for the Analyze Phase have been met, we conducted an Analyze Phase Tollgate Review for the Wegmans barbecue sauce project. Conducting the Analyze Phase tollgate review was very important in order to make sure that the finalized design meets customer expectations.

The elements of a ANALYZE Phase tollgate review are as follows[2].

1. Conduct Benchmarking **Yes**/No
2. Reduce the set of Potential Design concepts using Pugh Matrix **Yes**/No
3. Evaluate the concepts using Wal-Mart Scorecard **Yes**/No
4. Compare distribution systems using CAPE Analysis **Yes**/No

5. Pass the ANALYZE Phase Tollgate Review **Yes**/No

By successfully finishing the tollgate review, the Analyze Phase is completed and the project moves into Design Phase.

Design Phase

This is the fourth phase of the DMADV methodology. In this phase, the best design concept that was developed in Analyze Phase was converted in to a prototype[2].

The purpose of Design Phase is to create a prototype of the design model that will be studied in the Verify Phase. Creating a prototype helped the packaging team to visualize the concept and evaluate for potential problems that can be addressed prior to testing the final package for its distribution performance.

It is crucial to apply the Design Phase for the Wegmans barbecue sauce in order to create a prototype of the concept 4 that was developed in the Analyze Phase. By implementing the DESIGN phase, 12 prototypes of the Wegmans PET bottle was prepared. One corrugated tray package was also developed. Then the 12 PET bottles went into the corrugated tray and were ready for distribution testing in the Verify Phase.

This is an interesting phase of the DMADV methodology where the conceptual design concept is brought to existence. For successful completion of the Design Phase the following tool was used:

- Prototyping

Prototyping.

Prototyping is a process of creating a working model of the product, service or a process design that is under study[2]. With the help of prototypes, the packaging team can visualize the design and evaluate for the potential problems, and determine whether if any improvements are needed. This can help the packaging team to accelerate their decisions whether or not to make changes to their design.

The purpose of prototyping is to convert the conceptual packaging design concept into the physical/tangible form to validate the concept. The design is sent to the supplier, and the supplier creates the designs with the help of Rapid Prototyping. In this method, the products and parts are developed by inputting the technical specifications into the CAD program, which are then transferred to the computerized numerical controlled (CNC) machines. These machines create the prototype by following the set of instructions contained in the program.

It was crucial to apply the prototyping tool for the Wegmans project. By applying the prototyping tool, we were able to generate the primary and secondary packaging designs for our concept. These designs were then tested for distribution in the Verify Phase.

Prototyping for barbecue sauce: The bottle design created in the Analyze Phase was sent to the supplier to create a physical packaging design of the bottle. Also, a secondary package design was created. Please refer to Figure 13 showing the PET bottle and retail ready secondary tray package.

Figure 13: Final bottle samples ready for distribution testing

After receiving the samples from the supplier, the bottles were filled with barbecue sauce. These bottles were then placed in the secondary package. The secondary package was evaluated, based on the fit of the bottles. If required, the dimensions of the secondary package were revised. However, the secondary package was deemed acceptable, based on the fit of the bottles. The final dimensions of the secondary package were observed to be *10.206 x 7.886 x 8.028 in*

An additional benefit of the prototyping tool is that it allows us to gain a better understanding of the shelf space utilization. This is explained in Appendix 5. From Appendix 5, it is very clear that there is a 41% increase in the number of bottles on shelf, as compared to the current Wegmans glass bottle. The shelf presence has been increased, as compared to the old Wegmans glass bottle. Once the goals and objectives of the Design Phase have been met, we could successfully conduct a Tollgate review, and we were ready for testing the package in the Verify Phase. Conducting a tollgate review is the next step in the Design Phase.

Design Phase Tollgate Review.

A tollgate review is a checkpoint in a DMADV project where the team members meet and determine whether the team has successfully completed the previous phase or not and decide if they may pass the tollgate and move to the next phase. Tollgate reviews are carried out at the end of every phase in the DMADV project.

The purpose of the tollgate review is to make sure that the goals and objective of that specific phase have been met and that the team is ready to move to the next phase.

For the Wegmans barbecue sauce project, in order to ensure that the goals and objective for the Design Phase have been met, we conducted a Design Phase Tollgate Review for the Wegmans barbecue sauce project. This helped us to ensure that the package design that was conceptualized in Analyze Phase was now successfully brought to life size in the Design Phase. Conducting the Design Phase tollgate review is very important in order to make sure that the prototyped design meets customer expectations.

The elements of a DESIGN Phase tollgate review are as follows[2].

1. Build a Prototype using the final design **Yes**/No
2. Study Shelf Space Optimization **Yes**/No
3. Pass the DESIGN Phase Tollgate Review **Yes**/No

By successfully finishing the tollgate review, the DESIGN Phase was completed and the project moved into Verify Phase.

Verify/Validate Phase

This is the fifth and the last phase of the DMADV methodology. In this phase, the prototyped best design is validated for its intended functions by testing the design per ASTM distribution test methods. This is done to make sure that the design meets the customer's

requirements, like no damage being induced to packaging during distribution and product protection.

The purpose of Verify/Validate Phase is to[2]

- Test the prototype of the detailed design using ASTM Test methods
- Inspect the samples after testing
- Decide whether or not to scale up the design.
- Close the DMADV project

In order to validate the design concept (Concept 4) for the Wegmans barbecue sauce, it was very critical to implement the Verify/Validate Phase of the DMADV methodology.

By implementing the Verify/Validate phase, it was confirmed whether or not the design performs according to the customer expectations and requirements.

This is very important phase of the DMADV methodology as it involves validating the design that is the result of previous 4 phases of the DMADV project. For successful completion of the Verify/Validate Phase, the following tools were used:

1. ASTM Distribution testing
2. Data Analysis
3. Balanced Scorecard

ASTM Distribution Testing:

Distribution simulation testing is a uniform and repeatable way of evaluating packaging systems with the help of laboratory equipment by subjecting the packaging system to different shocks and vibrations that may occur within the anticipated distribution environment[15].

[15] "Distribution Simulation Testing" What is the industry doing. (2012, September 26). Retrieved from http://www.astm.org/COMMIT/presentation-files/DistributionSimulationTestingPresentation.pdf

Use of DMADV in Package Design

The primary purpose of the distribution testing is to have an effective shipping configuration that protects the product during routine transportation. A robust packaging design will ensure package integrity and protect the product during transit. After distribution conditioning, the package system is evaluated for package to product interaction, package integrity and product function based on the inspection criteria that is outlined prior to the testing.

When conducting distribution simulation, there are two different procedures that can be utilized:

1. ASTM International (American Society of Testing Materials)
    - D4169, "Standard Practice for Performance Testing of Shipping Containers and Systems"
    - D7386, "Standard Practice for Performance Testing of Packages for Single Parcel Delivery Systems"
2. ISTA (International Safe Transit Association)
    - 2 Series, "Partial Simulation Performance Tests"
    - 3 Series, "General Simulation Performance Tests"

The test procedure is selected based on the method that will accurately reflect the anticipated distribution environment.

For the Wegmans barbecue sauce, it was very important to subject the package to distribution conditioning. This would help us to ensure that the finalized package design (Concept 4) was robust enough to survive the hazards of the distribution environment. For the Wegmans package, ASTM test method was used, as it accurately reflects the anticipated distribution environment.

ASTM Distribution Testing for Wegmans Barbecue Sauce: After confirming the fit of prototype in secondary packaging, it was decided to conduct a distribution simulation on the package. Twelve samples of the PET bottle filled with barbecue sauce, and one sample of the secondary corrugated tray was ordered. The finished good was assembled and was subjected to ASTM D7386-12 (Standard Practice for Performance Testing of Packages for Single Parcel Delivery)[16]. This test method is effective since it covers shock and vibration tests for the package when it is transported as a single unit. This test method is considered to be worst case, as opposed to ASTM D4169 (Standard Practice for Performance Testing of Shipping Containers and Systems). This is because the package is subjected to more stress in ASTM D7386-12 than in ASTM D4169-14. Please refer to Appendix 6 for more information regarding test plan, inspection criteria, observations, and result.

From the observations/results found in Appendix 6, the new proposed PET bottle is very much efficient and has a robust design. No severe damages were found. All PET (concept 4) bottles passed the test. After receiving management approval, the new package design will be sent for full-scale production.

To understand the improvements made to the current Wegmans glass bottle, it is necessary to statistically analyze the new PET design. Statistical Analysis in the next tool that helped to identify this. With the help of this tool, we were able to get a better understanding of the profits if we plan to implement this design.

[16] ASTM D7386 - 12 Standard Practice for Performance Testing of Packages for Single Parcel Delivery Systems. (n.d.). Retrieved February 29, 2016, from http://www.astm.org/Standards/D7386.htm

Data Analysis.

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of discovering useful information, suggesting conclusions, and supporting decision-making[17].

The purpose of statistical data analysis is to statistically show the reader the summarized data. By using statistical analysis, we were able to draw inferences from the data. A graphical representation of the data helped to understand the improvements made.

It is very important to apply the data analysis section for the Wegmans barbecue sauce project. This allowed us to compare the two bottle designs statistically and also helped us understand the improvements that we were looking for in the new package to satisfy the customer.

Statistical analysis for Wegmans Barbecue Sauce: The new package design concept was found to be robust and effective after subjecting it to the distribution conditioning. Now let us compare this new package against the old glass bottle.

Table 7 below compares components of the old and new package design. The table shows the changes that have been in the new package.

[17] (n.d.). Retrieved February 29, 2016, from https://en.wikipedia.org/wiki/Data_analysis

Table 7.

Component Comparison of Old Glass Bottle v/s New PET Bottle

CTQ or CTP	Wegmans Old Bottle	New Design
Product Qty (cubic inches)	32.484	32.484
Bottle material	Glass	PETE
Bottle Weight	0.615lb	0.085lb
Cap material	Metal, liner	Polypropylene, continuous threaded 410-33mm, orifice reducer
Cap weight	0.010lb	PP cap- 0.005lbs Orifice reducer-0.010lbs
Label material	Paper, pressure sensitive	Paper, pressure sensitive,
Tamper Evidence	Paper wrap	Paper wrap, front and back, wrap around closure for tamper evidence
Bottle Dimensions	7.375 x 3.3125 x 2.0625	7.8750 x 3.3 x 1.8950

The new package has proved to be an improvement to the older version. Please see Table 8 below that shows the improvements that have been made by the newer package.

Table 8.

Improvements Observed in PET bottle

	Wegmans Glass	New PET Bottle	Improvements
Bottle Material	Glass	PETE	PET is more sustainable than Glass
Bottle Dimensions	7.1250" x 3.0625" x 3.0625"	7.8750" x 3.3000" x 1.8950"	N/a
Weight of Bottle	0.6250 lbs	0.1000 lbs	84% weight reduction
Cube Efficiency	50.85%	69.62%	27% increase in cube efficiency.
Package/Product Ratio	0.520	0.089	83% increase in pkg/prod ratio
Bottles per Pallet	1008	1320	24% increase in bottles per pallet
Bottles per truck	44352	66360	34% increase in bottles/truck
Bottles on Shelf (assume shelf size of 48" x 9" x 18")	75	126	41% increase in shelf storage
Number of trucks required to ship 1million bottles	23	16	7 less trucks needed to ship

As shown in able 8 above, significant improvements have been made in the new PET bottle design. For example, to ship 1 million bottles, seven fewer trucks are needed with the new PET bottle design. Let us try to understand the math. Wegmans uses 6 axles 53 footer truck. Based on the information from Wegmans representative, the truckload weight limit is 100,000 lbs. According to the CAPE Analysis performed for the Wegmans glass bottle, the weight of the load is 96524.2 lbs, which does not exceed the truckload limit of 100,000 lbs. Also, for the PET bottle

the weight of the load is 95775.6 lbs, which does not exceed the truckload limit of 100,000 lbs. Please refer to Figure 14 and Figure 15 below.

Due to the cylindrical shape of the Wegmans glass bottle, only 44352 bottles can be shipped per truck. But in case of the cube-efficient PET bottles, 66360 bottles can be shipped. One thing that should be noted is, although the weight of the load shipped in the truck is almost same, the quantity of the bottles shipped is different. By using concept 4-PET Bottle design, 34 % more bottles can be shipped per truck.

So, basically, to ship 1 million bottles, 16 trucks will be used with the new improved PET bottle design, as opposed to 23 trucks with the older Glass bottle. This means that there is 31 % reduction in the fuel consumption and hence 31% reductions in CO_2 emissions. (Reduction in CO_2 emissions has been calculated relative to the Wegmans Glass bottle).

	Length	Width	Height	Net	Gross
Case (OD)	13.000	10.000	7.500 in	21.750	22.815 lb
Product	46.000	40.000	45.000 in	1827.000	1916.460 lb
Load	48.000	40.000	50.500 in	1916.460	1966.460 lb
Product	528.000	80.000	101.000 in	84324.2	86524.2 lb
53footer	636.000	96.000	102.000 in	86524.2	96524.2 lb

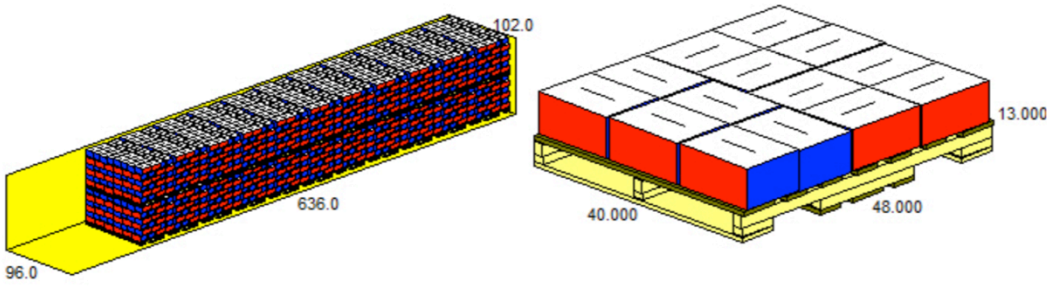


Figure 14: CAPE Analysis - Wegmans Glass Bottle

	Length	Width	Height		Net	Gross	
Rectangu	(OD)	3.300	1.895	7.875	in	1.188	1.288	lb
Tray	(OD)	10.206	7.886	8.028	in	15.450	15.791	lb
Product		47.284	38.465	40.140	in	1699.500	1737.010	lb
Load		48.000	40.000	45.640	in	1737.010	1787.010	lb
Product		576.000	80.000	91.280	in	83375.6	85775.6	lb
53footer		636.000	96.000	102.000	in	85775.6	95775.6	lb

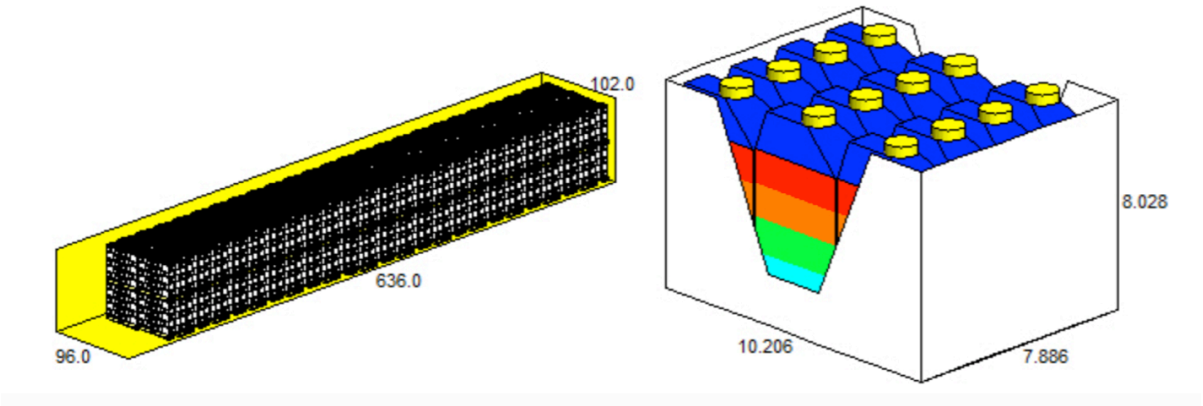


Figure 15: CAPE Analysis - Wegmans PET Bottle (Concept 4)

The improvements shown above are captured graphically as shown below.

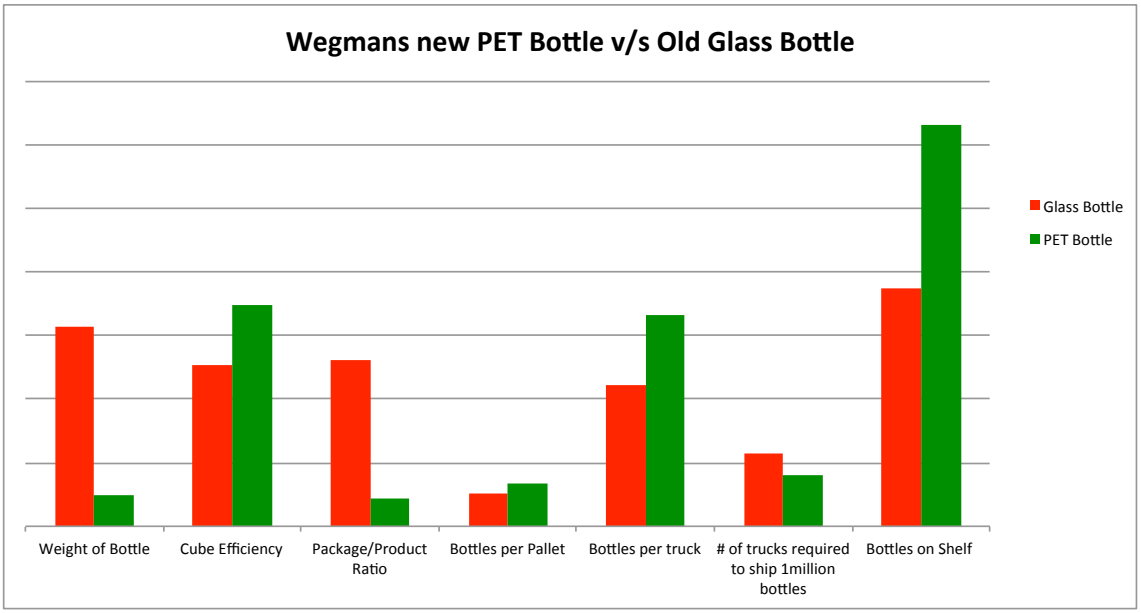


Figure 16: Graphical Representation Of Comparison of Wegmans Glass v/s Wegmans PET Bottle

From the data shown in graph in Figure 16, it is very clear that some improvements have been made.

Design Improvements:

- The weight of the bottle has been reduced. This means that less fuel will be consumed by the newer packaging design.
- The cube efficiency has increased.
- The package-to-product ratio has been reduced. This means that less material will be consumed.
- The bottles per truck have been increased. This means that more products can be transported in the same truck. This can reduce the transportation costs.
- And lastly, the number of bottles on the shelf has been increased. This means that the shelf presence has been increased which will help to boost sales. Also, the retailer does not have to frequently load the bottles on the shelf.

Sustainability Improvements:

- From Table 8, it is very clear that, with the new improved PET bottle, seven fewer trucks are now needed to ship one million bottles. This means there is a 31% reduction in CO2 emissions from truck optimization.
- As shown in Table 7, the use of orifice reducer will help reduce product waste since that will provide controlled flow of the barbecue sauce.
- Also from Wal-Mart scorecard, there is a reduction in the overall environmental impact of the new package design.

Cost Savings:

- With the Wegmans old bottle, 23 trucks were needed to ship 1 million bottles. With the new improved design, only 16 trucks are needed to ship the same amount of bottles. This infers that there is a 30% cost savings due to the implementation of the new packaging design. Depending on the sales made by Wegmans and by finding out the cost per trailer, approximate transportation savings can be calculated.

From the Data Analysis section, it has been proved that the new package design is efficient and satisfies customer requirement, while reducing the environmental impact. After conducting the data analysis, it is now important to understand the financial implications of this design, the effects on the internal business process, whether or not the design has met customer requirements, and what additional training will be required to develop the employees. Balanced Scorecard is a tool that will help us to understand this by addressing these questions in a documented format. Balanced Scorecard (BSC) is the next tool in this Phase.

Balanced Scorecard.

The balanced scorecard is a strategic planning and management system that is used extensively in business and industry, government, and nonprofit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals[18].

[18] Perspectives. (n.d.). Retrieved February 29, 2016, from http://balancedscorecard.org/Resources/About-the-Balanced-Scorecard

The purpose of Balance scorecard is to provide a framework that provides performance measurements, along with what should be done and measured. The Balanced Scorecard focuses on creating and communicating a total comprehensive picture to all members of the organization from the top down, taking a long-term view of what the company's strategic objectives really are, making good use of knowledge gained through experience, and maintaining the required flexibility of such a system to cope with the fast-changing business environment[1]. Balanced Scorecard provides a more balanced view by looking at not just financial concerns, but also customers, internal business processes, and learning and growth. Please refer to Figure 17 below.

It is crucial to apply the Balanced Scorecard tool to the Wegmans project in order to provide feedback around both the internal business processes and external outcomes to continuously improve strategic performance and results. This will help to transform strategic planning from an academic exercise into the nerve center of an enterprise.

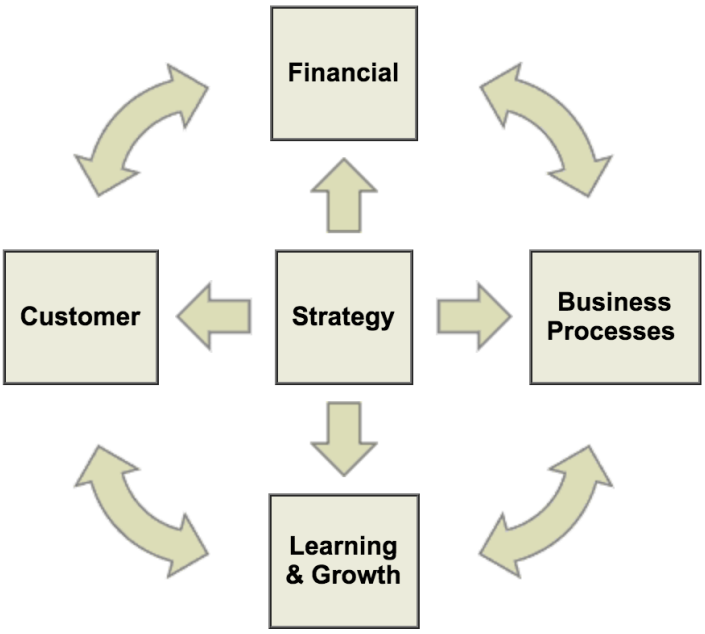


Figure 17: A General Balanced Scorecard

Balanced Scorecard for Wegmans Barbecue Sauce: The balanced scorecard takes a look at the organization from four different perspectives and develops metrics, collects data, and analyzes it, relative to each of these perspectives[19]:

1. Learning and Growth Perspective
2. Internal Business Process Perspective
3. Customer Perspective
4. Financial Perspective

Learning and Growth Perspective: This perspective focuses on employee training and improving corporate cultures attitudes related to individual and corporate self-improvement. In this fast growing and rapidly changing industrialization, it is very important to schedule continuous learning opportunities for the employees to keep them knowledgeable and well trained.

For the Wegmans Project, knowledge on various materials and manufacturing technologies was very important. It is also important to have a holistic understanding of the current supply chain. Different training sessions were organized for the team members in order to keep them updated with the latest technologies. This would enable them to make efficient decisions that would be beneficial for the company. Moving forward periodic training sessions on latest materials and technologies will be arranged for the employees so that they can make wise decisions related to individual projects. This holistic approach is very necessary so that we

[19] Perspectives. (n.d.). Retrieved March 02, 2016, from http://balancedscorecard.org/Resources/About-the-Balanced-Scorecard

can save on time required for training the employees at the last minute, as well as avoid the costs due to design errors occurring due to having untrained employees.

Internal Business Process Perspective: This perspective refers to internal business processes of the company. This perspective allows the managers to get a clear idea about their business performance and discover whether or not their products are making the customers happy.

For the Wegmans project, it is very important to gain an understanding of the supply chain. What changes do we need to make to our package, so that it flows through the supply chain without impacting the segments of the supply chain? How can we efficiently design a business process to make this happen? Since we moved from Glass to PET, we have significantly optimized our supply chain. PET containers weigh less than glass, which results in lighter packaging/ lighter loads, fewer trucks, reduced transportation energy, decreased emissions, and lower shipping costs. The distribution costs have been significantly reduced. From a long-term perspective, the company should use these strategies in the future to improve its performance and make their customers happy. The customers would get a feeling that the company is socially responsible and is trying to reduce the environmental impact by deploying such strategies. This is called Corporate Social Responsibility. Employing such strategies will also be beneficial for the company. The Internal Business perspective should facilitate the company to have

- Better Supply chain management
- Better Distribution
- Social responsibility
- Process Alignment

Customer Perspective: Companies understand that customer focus and customer satisfaction is an important attribute for any business to succeed. We need to create products that are satisfying the customer needs in order to retain them. If these two metrics are performing poorly, then the business is about to decline. In order to understand these metrics, we have to understand our customer requirements our process limitations and, based on them, we should design our product.

For the Wegmans project, the customer perspective is of crucial importance. Based on the sales data received from Wegmans, the sales of the barbecue sauce were declining even though it is popular in barbecue sauce category. A SWOT analysis was performed to understand the current package. Based on the Opportunities and Threats observed, an action plan was put in place to a grab the opportunities and address the threats in an efficient manner.

Then a survey was conducted to understand the customer requirements. The end user wanted a lightweight bottle that was easy to handle and enhanced the pouring performance of the sauce. The customers involved in the product supply chain (retailer, manufacturing organizations) were looking forward to a bottle that would be easy and cost-effective to manufacture, support the distribution systems, and have less impact on the environment. All these metrics were not completely addressed by the Current glass bottle. So it was decided to create a new package that would address these metrics efficiently and would make the end user, as well the intermediate customers, of the supply chain happy. To address these requirements, the glass bottle was revamped to a PET bottle. As we all know, PET is a sustainable and an efficient choice over glass bottle in terms of manufacturing, distribution, and end of life cycle. The aesthetics of the bottle were improved significantly. This overall change in the Wegmans bottle improved its shelf presence, thereby improving the sales of the Wegmans barbecue sauce.

Thus by understanding the customer's perspective the organization can sustain in today's competitive environment.

Financial Perspective: The Financial Perspective ensures that the company's strategy will contribute to its progress. The Financial Perspective expresses the long-term strategic objectives of the organization in tangible outcomes of the deployed strategy in traditional financial terms. Depending on the strategy, two objectives are crucial, i.e. Revenue Growth Objective and Productivity Objective.

Revenue Growth objective can be achieved by

- Developing new revenue sources
- Improving current profitability

Productivity Growth objective can be achieved by

- Decreasing the costs
- Optimizing resources

It is crucial to apply the financial perspective to the Wegmans project to increase revenue, reduce costs, and increase the profit margins by boosting the sales. As mentioned above, two objectives would be crucial depending on the strategy, i.e. Revenue Growth Objective and Productivity Objective.

Revenue Growth Objective: In order to increase the revenues for the Wegmans barbecue sauce, it was decided to revamp the current package. The new bottle was completely redesigned to be an attractive, lightweight, and user-friendly bottle. The new bottle successfully met and exceeded the customer's expectations thereby increasing the sales. This generated additional revenue for the project.

In order to increase the revenue growth, a line extension of the new package was suggested. It was recommended to create seasonal packs of five different flavors during the summer season. This strategy turned out to be profitable, and the objective of Revenue Growth was achieved.

Productivity Growth Objective: In order to achieve this objective for Wegmans barbecue sauce, we needed to reduce our costs associated with various elements and optimize the resources for the same. The main elements that could help to reduce cost and optimize resources were Raw Material, Manufacturability and Energy Consumption, Distribution, Waste Generation. These elements are explained in detail below.

Raw Material: As observed in the Data Analysis section, there was an 84% reduction in the weight of primary package material. This means that the raw material consumption was reduced by 84%. The costs attributed towards the raw material have been significantly reduced. Also, reduction in material consumption advocates resource optimization.

Manufacturability and Energy Consumption: The total energy required to produce and transport the glass bottle is 34MJ/16oz bottle, as opposed to 32 MJ/16oz plastic bottles[20]. By using plastics in their packaging, product manufacturers save enough energy every year to power a city of 1 million homes for 3-½ years[3]. Moving from glass to plastic can definitely reduce manufacturing costs and optimize energy consumption.

Distribution: From the Data Analysis section, there was a 34 % increase in bottles per truck with the new improved PET package. To ship 1 million bottles, we would need 16 trucks of PET bottles, as compared to 23 trucks of Glass bottle. This is nothing but "Truck Optimization". So moving from Glass bottle to a plastic bottle (PET) has not only increased the

[20] Glass vs. Plastic. (n.d.). Retrieved March 1, 2016, from https://ay14-15.moodle.wisc.edu/prod/...php/.../glass_vs_plastic.ppt?

number the bottles per truck, but has also reduced the fuel consumption since plastic is lighter than glass. There is a 31% reduction in fuel consumption and 31% reduction in CO_2 emissions.

Also, plastic bottles are more appealing, functional, and easier to stack on the shelves, which is important from the retailer standpoint.

Another advantage of the revised design is a retail-ready secondary tray package. The tray package allows the stacking of 12 PET bottles all at the same time, instead of stacking one bottle on the shelf, which was the case with glass bottles. All the 12 bottles can be accessible through the tray package. This saves labor costs by reducing the number of store personnel. It also saves time in loading the bottles on the store shelf. This is resource optimization.

By applying these approaches, we are able to reduce the project costs and optimize our resources, thereby supporting the financial perspective of our organization's strategy.

Waste Generation: Since glass is breakable, it ends up being landfilled. According to US EPA, 11.5 million tons of glass was recovered[21] from municipal solid waste (MSW), as opposed to 33 million tons of plastic[22]. 27% of recovered glass bottles were recycled, as opposed to 31% of PET bottles. Also, plastic containers use less energy to recycle. By moving from glass to plastic, we have observed a reduction in breakage or damaged goods by 90%[23]. This has reduced the charge-backs from the retailers significantly.

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[21] Glass. (n.d.). Retrieved March 02, 2016, from http://www3.epa.gov/epawaste/wastes_archive/glass.htm

[22] Plastics. (n.d.). Retrieved March 02, 2016, from http://www3.epa.gov/epawaste/wastes_archive/plastics.htm

[23] Shattering the Myth: Plastic vs. Glass. (n.d.). Retrieved March 1, 2016, from www.pretiumpkg.com/wp.../Shattering-the-Myth-Plastic-vs-Glass-P.pdf

By employing such strategies, one can reduce the potential costs and also optimize the available resources.

The Balanced Scorecard designed for Wegmans has successfully provided framework to measure performance, along with what should be done and measured. The Balanced Scorecard discussed above has successfully communicated a total comprehensive picture to all members of the organization from the top down, taking a long-term view of the company's strategic objectives and making good use of knowledge gained through this project. The Balanced Scorecard takes into consideration a more balanced view by looking at not just financial concerns, but also customers, internal business processes, and learning and growth.

After the completion of Balanced Scorecard, it was then necessary to ensure that the goals and objectives of Verify/Validate phase had been met, and that we were ready to close this project. Tollgate review is the next tool that helped us to ensure this.

Verify/Validate Phase Tollgate Review:

A tollgate review is a checkpoint in a DMADV project where the team members meet and determine whether the team has successfully completed the previous phase or not, and if they may pass the tollgate and move to the next phase. Tollgate reviews are carried out at the end of every phase in the DMADV project.

The purpose of the tollgate review is to make sure that the goals and objective of that specific phase have been met and that the team is ready to move to the next phase.

For the Wegmans barbecue sauce project, in order to ensure that the goals and objective for the Verify/Validate Phase have been met, we conducted a Verify/Validate Phase Tollgate Review. The new Concept 4 design (PET Bottle) was evaluated for its performance using the ASTM distribution testing. The package was observed to be robust and showed no signs of

damage. Additionally, the strategies implemented during the execution of this project were documented using a Business Scorecard (BSC). Documenting theses strategies allowed us to revisit them if a similar project is identified in the future. Conducting the Verify/Validate Phase tollgate review is very important in order to make sure that the design is robust and that the strategies have been documented.

The elements of a Verify/Validate Phase tollgate review are as follows[2].

1. Evaluate the prototyped design using ASTM distribution testing **Yes**/No
2. Generate Balanced Scorecard to achieve strategic goals and objectives **Yes**/No
3. Close the DMADV Project by documenting it in the system **Yes**/No
4. Pass the VERIFY/ VALIDATE Phase Tollgate Review **Yes**/No

By successfully finishing the tollgate review, the DMADV project is successfully completed. The design is turned over to the appropriate process owner with the project plan. If there are any improvements/ line extensions to the product as an evolution in the future, the process owner gets notified. The process owner collects data on whether or not the design is achieving its business objectives, and generates appropriate accounting documentation on the project's benefits/costs.

Results

As seen in the Methods section, DMADV has been proved to be an effective tool. It has been recognized that DMADV uses an organized approach to address the problem. Clearly stated, the Wegmans glass bottle was designed using a traditional approach that was just able to partially meet the customer's expectations. Some of the expectations were not completely fulfilled, and thus the sales of the barbecue sauce experienced a drop. Please refer to Table 8 Improvements Observed in PET Bottle in the Data Analysis tool of the Methods section. From the table, it was observed that the current Wegmans glass bottle was heavy, was less cube-efficient, and used more material to ship the product. Also, it required more trucks to ship the product, as compared to the new improved PET bottle. What does this mean? This means that we did need a more standardized and organized approach to address the customer's requirements – the DMADV. The traditional approach lacked structured problem-solving organization; the package needed to be redesigned to meet customer's expectations.

Also, from the Literature Review section, it has been found that companies used different design processes for creating packages. What the industry needs is a universal process for designing the packages that can be used across the board. The DMADV. It is a value-added and non-traditional approach for addressing the same problem. The advantage of using a DMADV process is that it is a reliable process and is very well organized.

As seen in the Literature Review and Methods section traditional approach focused on spot improvements. In order to meet the customer requirements, the package was undergoing frequent improvements. Although the package was improvising gradually, the time, cost and the resources required for making these improvements were increasing, which had an adverse effect on the business. In the Methods section, DMADV revealed an organized and structural approach

to address the same problem of package design. DMADV used a holistic approach of finding a solution to the problem by not only addressing the current issues, but also focusing on the problems of tomorrow. For example, one of the customer requirements was easy pouring of the barbecue sauce. The traditional approach failed to achieve this expectation. The non-traditional DMADV approach successfully met the expectation by using a flexible material like PET that was squeezable and exceeded the expectation by adding an orifice reducer to allow controlled flow of glass. This is called as holistic approach, in which the current issue is addressed; in addition, problems that would occur in the near future are addressed.

Since the non-traditional DMADV approach is a documented phase-by-phase holistic approach, there is very little room for error, as opposed to the traditional approach that involves a silo approach. From the Balanced Scorecard, it was revealed that periodic training sessions were organized for the team members in order to keep them updated with the latest technologies. This holistic approach is very necessary, so that companies can save on time required for training the employees at the last minute, as well as avoiding costs due to design errors occurring due to untrained employees. By adopting the non-traditional DMADV approach, the time, money and resources invested on a project are optimized to create efficient package design with less environmental impact.

Another important point to be considered is the impact on the distribution system of the product. Every company has its truck limitations documented in the system. For Wegmans, the truck limitations were 6-axle, 53-footer trucks, with a truckload weight limit of 100,000 lbs. After implementing the DMADV methodology and performing CAPE Analysis, it was found that 66,360 PET bottles were shipped, as opposed to 44,352 glass bottles in the same size truck.

By implementing the DMADV approach, 34 % more bottles were shipped per truck. Considering the larger impact, seven fewer trucks were used to ship 1 million PET bottles, compared to the glass bottles. The improved PET bottle design used 31% less fuel and had 31% less CO_2 emissions. (Reduction in CO_2 emissions was been calculated relative to the Wegmans glass bottle). The DMADV approach has again proved its significance.

In the Methods section, the PUGH matrix tool used in the ANALYZE phase of the DMADV Methodology helped to meticulously evaluate the potential package designs and to come up with a final package design (Concept 4 – PET Bottle). This tool was not used in the traditional approach, and hence lacked the packaging attributes that could be evaluated.

The most important tool used in the DMADV methodology was the House of Quality tool. This tool helped to capture and display a wide variety of important design information in one place and in a compact form. The main benefits of House of Quality were

- Greater likelihood of product success in the marketplace, due to the precise targeting of key customer requirements
- Reduced overall design cycle time, mainly due to a reduction in time-consuming design changes. This is a powerful benefit. Customer requirements are less likely to have changed since the beginning of the design project, and more frequent design cycles mean that products can be improved more rapidly than the competition.
- Reduced overall cost due to reducing design changes, which are not only time consuming, but very costly, especially for those that occur at a late stage.
- Reduced product cost by eliminating redundant features and over-design.

The traditional approach lacks these tools, and therefore, more frequent design changes occur. By increase in the frequency of design changes, time, money and resources are wasted.

Based on the findings in the Results section, the non-traditional DMADV approach has proved to be efficient in redesigning the Wegmans package along with improving the sustainability metrics. The traditional approach did not prove to be efficient as seen from the Wegmans glass bottle design. The traditional style focused on the data and information learned in the Methods section. The non-traditional approach presented the packaging engineers an innovative way to design packages.

Discussion

From the Results section, DMADV has proven its value to be an effective and efficient process to develop packages in the food industry. As seen in the Methods section, DMADV helped to improve the Wegmans package. DMADV used a step-by-step approach to resolve the problems faced by the current Wegmans barbecue sauce package. Given below is a step-by-step description of how DMADV proved to be an effective methodology to resolve the package design issue.

Define Phase

In this first phase of DMADV, a business case was developed to identify the problems with the current package and propose how a solution can be implemented to resolve this problem. Then a SWOT analysis was performed on the current bottle to identify the Strength and Weaknesses of the bottle, the opportunities for improvement and the threats with respect to its competitors. All this previous information helped to develop an opportunity statement that described the current and desired state of the problem in clear concise and measurable terms. Once the opportunity statement was developed, the Project Objective became clearer. Developing the project objective helped to determine the deliverables needed to achieve the customer expectations in a SMART- (Specific, Measurable, Attainable/Achievable, Realistic, and Time-bound) way. After developing the project objectives, it was easy to determine the in-scope and out-of-scope elements for the project that would allow us to strictly focus on the area under consideration for the project. Then, the Project plan and Project Charter was developed that assisted in identifying the detailed project goals, roles and responsibilities, stakeholders and timeline for the project. By performing a tollgate review at the end of Define Phase, it was

verified that all the goals and objectives of this phase had been met and that the project was ready to enter the Measure phase.

All the information described above is captured in one place and in compact form in Figure 18, later in this chapter. Please refer to Figure 18 to understand steps used in DEFINE Phase of the DMADV process for the Wegmans barbecue sauce.

Measure Phase

This was the second phase of the DMADV methodology. Firstly, the lifecycle of the Wegmans barbecue sauce package was understood with the help of Process Flowchart. This not only helped to understand and communicate the process to the team, but also assisted in determining how the improvements could be made to the current barbecue sauce package. After developing the process, it was important to understand the market and customer expectations. Conducting market research and retail audits of the entire barbecue sauce category proved to be elemental in understanding the growth and sales of barbecue sauce in coming years.

After receiving the feedback from the surveys, customer requirements were converted into CTQs with the help of House of Quality tool. This tool proved to be of great significance because it helped to capture the voice of the customer and translate it into services to meet the customer requirements. It was with the help of this tool that we were able to create a relationship between WHAT the customer wants and HOW are we going to meet those expectations. This tool proved to be of great importance in identifying where the package needs to be improved to meet the customer requirements. By performing a tollgate review at the end of Measure Phase, it was verified that all the goals and objectives of this phase had been met and that the project was ready to enter the Analyze phase.

The activities performed in the measure phase above are captured in one place and in compact form in Figure 18later in this chapter. Please refer to Figure 18to understand steps used in Measure Phase of the DMADV process for Wegmans barbecue sauce.

Analyze Phase

Analyze Phase was the third phase of the DMADV methodology where a best design concept was developed to address the voice of the customer. With the help of the Benchmarking tool, different packaging concepts that were available in the market were evaluated with respect to the current Wegmans glass bottle to understand the faults in the current package. It was then understood that PET was more commonly used in the market, the design was more cubicle, and it was important to add a design feature that would assist the pouring of the barbecue sauce. Based on these findings, five alternative concepts were developed for the Wegmans barbecue sauce package. These concepts were then evaluated with the help of the PUGH matrix. The Pugh matrix was a crucial tool that provided the team with a holistic view of needs v/s different alternatives in the form of a matrix, instead of listing down the positives and negatives of each option. It significantly reduced the time taken by the team to analyze the scores, as compared to deploying the wrong solution to a project. The Concept 4 PET Bottle came out as winner. Then the Wal-Mart Scorecard helped to evaluate the concept, relative to the baseline concept based on specific metrics like Carbon footprint, Water print, Cube Utilization and many more. The best final package design was approved by Wal-Mart scorecard and was found to way more superior than the current Wegmans glass bottle. To understand the implications of the new package design, a CAPE analysis was performed on the new and old bottle designs. From the CAPE analysis, it was found that 43% more bottles could be shipped with the new improved PET

package design. Also, fuel consumption and CO_2 emissions were reduced by 31%. These were significant advantages over the current glass bottle. At the end of the Analyze Phase, a tollgate review was conducted to verify that all the goals and objectives of this phase had been met and that the project was ready to enter the Design phase

The activities performed in the Analyze Phase above are captured in one place and in compact form in Figure 18 later in this chapter. Please refer to Figure 18 to understand steps used in Analyze Phase of the DMADV process for Wegmans barbecue sauce.

Design Phase

The fourth phase of the DMADV methodology where a prototype of the final design concept was created and studied for shelf space optimization. By creating a working model of the design concept, it became easier to evaluate the design and decide whether any improvements were required to be made to the design. The primary and secondary package designs were generated for the Wegmans barbecue sauce. Prototyping the PET bottles also allowed us to evaluate their shelf space utilization. There appeared to be a 41% increase in the number of bottles on shelf, as compared to the current Wegmans glass bottle. The goals and objectives of this phase were met in the Tollgate review, and the project was ready to enter the Verify/Validate Phase.

The activities performed in the Design Phase above are captured in one place and in compact form in Figure 18 later in this chapter. Please refer to Figure 18 to understand steps used in DESIGN Phase of the DMADV process for Wegmans barbecue sauce.

Verify/Validate Phase

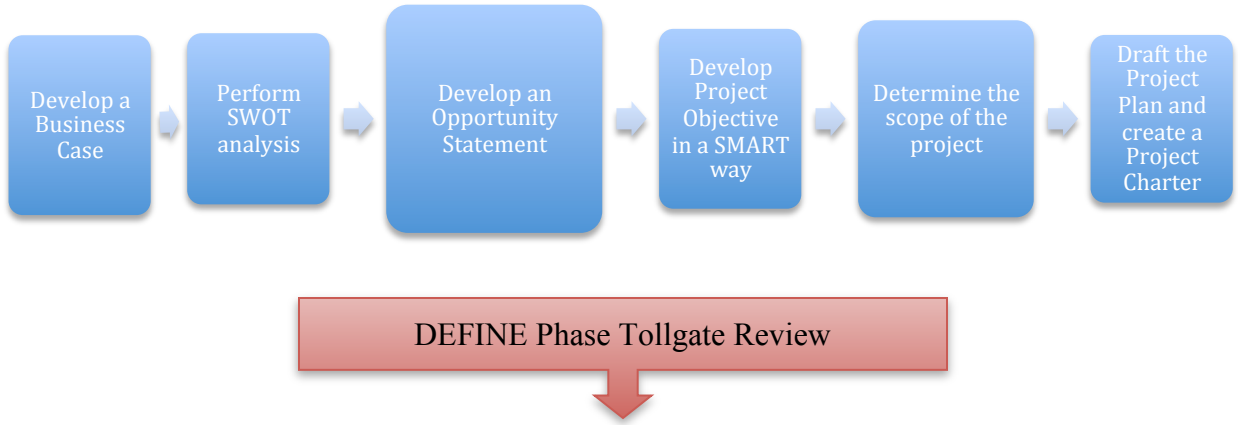
This was the last and most important phase of the DMADV methodology as it involved validating the design, analyzing the improvements made in the new bottle design, and generating a Balanced Scorecard for the internal business processes and external outcomes to continuously improve strategic performance and results.

After developing samples by prototyping, ASTM distribution testing was conducted on those samples. All the samples passed the test. This new design was then compared against the old Wegmans glass bottle to understand the improvements made. This strategy turned out to be effective and was documented using a Balanced Scorecard tool. This tool successfully communicated a complete comprehensive picture to all members of the organization from the top down, taking a long-term view of what the company's strategic objectives and making good use of knowledge gained through this project. The Balanced Scorecard takes showed a more balanced view by looking at not just financial concerns, but also customers, internal business processes, and learning and growth. By performing a tollgate review at the end of Verify/Validate Phase, it was verified that all the goals and objectives of this phase had been met and that the project was successfully completed.

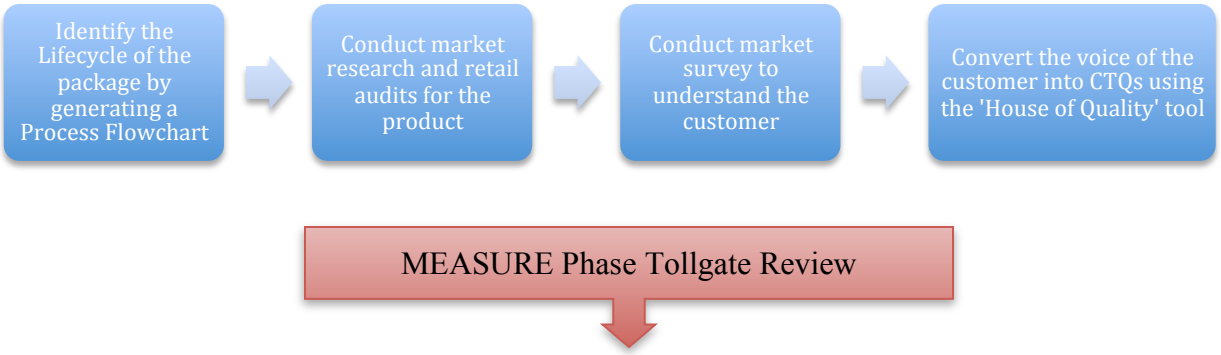
The activities performed in the Verify/Validate Phase above are captured in one place and in compact form in Figure 18 later in this chapter. Please refer to Figure 18 to understand steps used in DESIGN Phase of the DMADV process for Wegmans barbecue sauce.

Based on the discussion above, DMADV has proved to be very effective in redesigning the Wegmans barbecue sauce package. It is now time to document this step-by-step process into a DMADV model for packaging industry. Please refer to Figure 18 below for the DMADV model for designing packages.

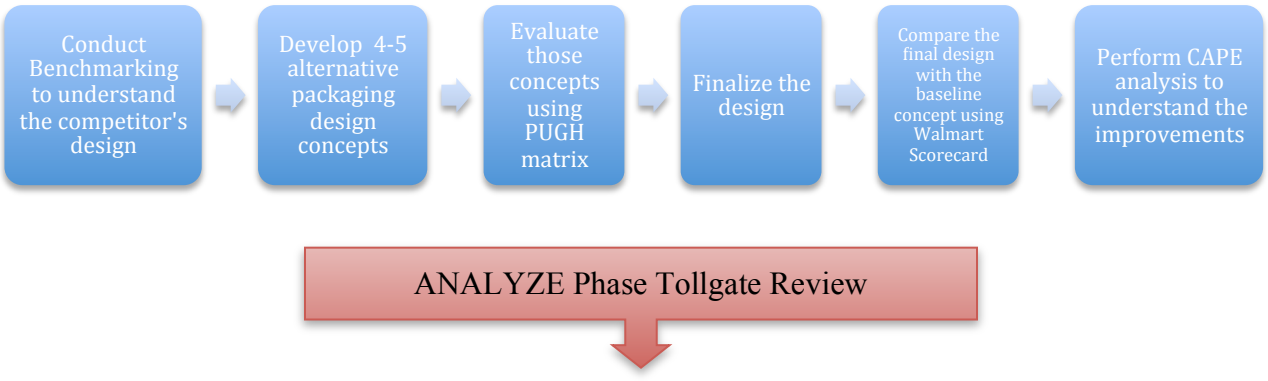
DEFINE PHASE



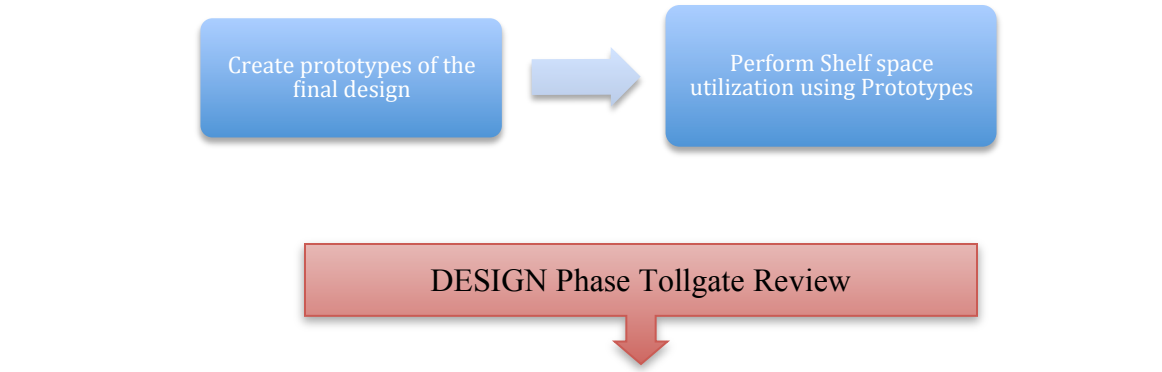
MEASURE PHASE



ANALYZE PHASE



DESIGN PHASE



VERIFY/VALIDATE PHASE

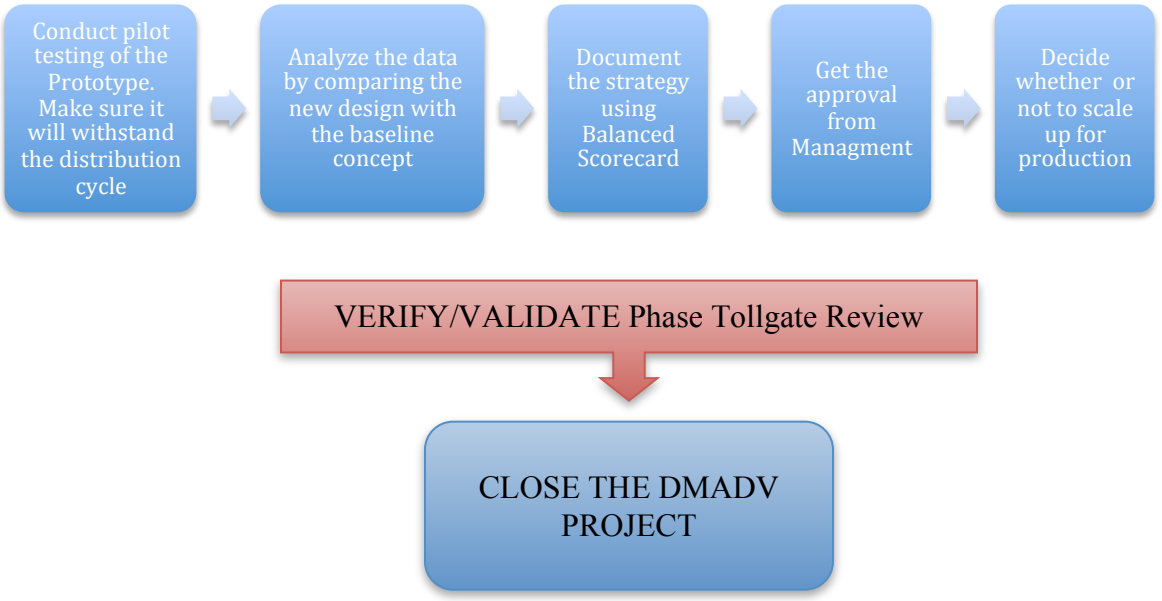


Figure 18 DMADV Model for Designing Packages

Figure 18 above shows a final standardized process for designing the packages. It explicitly documents the activities performed in each of the DMADV Phases. For the detailed activities and tools to be used during each phase, please visit the respective DMADV phases.

Figure 19 below graphically shows the advancements made in the new package by implementing the DMADV methodology to the Wegmans barbecue sauce. As shown in Figure 19, below the new PET bottle is lightweight, is more cube-efficient, and uses less packaging material. Since the PET bottle is more cube-efficient, more PET bottles fit on the pallet, and hence more bottles can be distributed in the same truck. Also, due to the cubicle shape of the PET bottle, more bottles can fit on the shelf, thereby increasing shelf presence. The DMADV process has significantly helped to improve the package. This process has been so optimized that it can, not only be used to improve the current packages, but also to develop new packaging concepts for new products that will be implemented in the market.

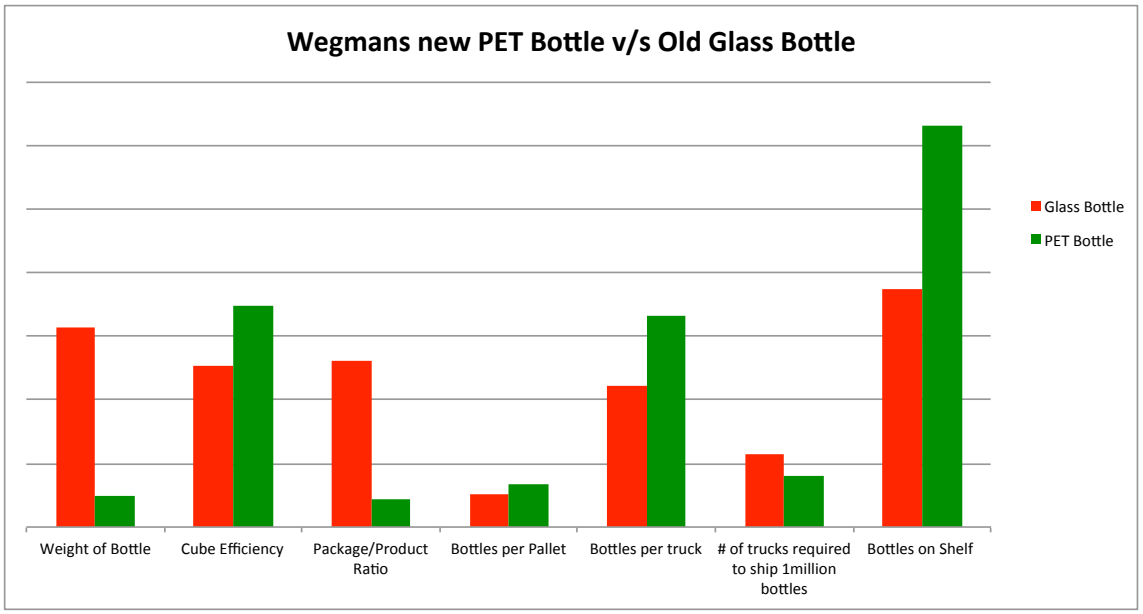


Figure 19: Graphical Representation Of Advancements made to Wegmans Glass Bottle

Conclusion

Based on the Results and Conclusion section, it is very clear that the nontraditional DMADV methodology is effective in addressing the problems that arise during designing a package. The packaging engineers will definitely benefit from this approach. The lean six-sigma DMADV methodology is currently being used in different industries to optimize a process and benefit from this structural approach. By applying this DMADV methodology to one of the packaging design projects (Wegmans), several benefits were achieved. Similar benefits can be gained by applying this DMADV package design model that are given below:

- A holistic approach at designing the package, which focuses not only on the customer requirements, but also on the impacts that the package design would create on the environment.
- The entire supply chain of the product gets well managed. The process adds a value to every step of the entire supply chain.
- There is a sales boost, which directly leads to increase in the revenue of the product.
- The organization costs are reduced.
- Productivity is increased, thereby leading to profits.
- There is an increase in efficiency and effectiveness of the package designing process.
- The customers and employees are more satisfied.

The packaging industry should take an advantage of this package design model to develop packages that will prove to be more effective in the entire supply chain and will be more sustainable.

Lastly, since the packaging industry is not entirely aware of the five phases of the DMADV, there exists a need to educate and train packaging professionals on this problem-solving design methodology.

Packaging engineers and their organizations will benefit from DMADV training sessions. Training would standardize the package engineering designing process, minimize design errors and reduce the time to market costs.

APPENDICES

Appendix 1 - Project Charter

PROJECT NAME: Wegmans Barbecue Sauce			
Start Date	8/1/2015	**Completion Date**	1/5/2016
Leadership Name	Sumeet Deshpande	**Champion Name**	Professor Karen Proctor

Element	**Description**	**Team Charter**
Objective Statement	What is the objective to be achieved?	Enhance the current Wegmans glass bottle to a new lightweight, handy and easy to pour plastic bottle in next two months. The project estimates that the new bottle design will be 15% more cube efficient, use 80% less material and will reduce the transportation and handling costs by 30%. Also the new plastic bottle will be 30% more sustainable and will reduce product waste
Project Scope	Which part of the process will be investigated?	Enhancement of current barbecue sauce glass bottle to improve user experience, sustainability and to efficiently achieve the goals of the supply chain
Team Members	Who is on the team, internal and external personnel?	Packaging Team, Industrial Team and Graphics Team
Project Schedule	What is the projected completion date timeline for the project?	The completion date is to be done before Jan 5, 2015 however that is the absolute maximum time that can be allotted for this project.

Phases	**Goals and Start Date**	**Tools Used**	**Phase Work Approved Date and Initials**
Define	Start at 1/8/15 to define and produce a business case, opportunity statement, project objective, Project Scope, Project Plan and Project charter for the Wegmans Project	1. Business Case 2. SWOT Analysis 3. Opportunity Statement 4. Project Objective 5. Project Scope 6. Project Plan 7. Project Charter	

Measure	Start this phase on 1/8/15 to measure various attributes using Process Flowchart, conduct market survey and retail audits and determine the CTQs using Quality Function Deployment	1. Process Flowchart 2. Market Survey 3. Quality Function Deployment (House of Quality)	
Analyze	Start at 9/8/15 to set baseline to develop a improved bottle design using Benchmarking, evaluate various bottle designs using Wal-Mart Scorecard and PUGH matrix, and to evaluate transportation rating using CAPE Analysis	1. Benchmarking 2. Wal-Mart Scorecard 3. CAPE Analysis 4. Pugh Matrix	
Design	Start at 12/14/15 to build a actual PET bottle and a retail ready tray as a secondary package by using Prototyping tool.	1. Prototyping	
Verify	Start at 12/20/15 to conduct a distribution testing on the finalized package in order to qualify it for mass production.	1. Distribution Testing (ASTM) 2. Data Analysis 3. Balanced Scorecard (BSC)	

Appendix 2 - House Of Quality For Wegmans Barbecue Sauce

				Column #	1	2	3	4	5	6	7	8											
				Direction of Improvement:	▲	▼	x	▲	▼	▲	▲	x	Competitive Analysis										
Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality	Packaging Material	Package Weight	Tamper Evidence	Cube Efficiency	Cost	Sustainability metrics	Pallet Stability	Design Features	Wegmans	Competitor 1	Competitor 2	Competitor 3	Competitor 4	0	1	2	3	4	5
1	3	7.9%	3	Product Visibility	O				▲			▲	3	4	3	4	4						
2	9	13.2%	5	Product Protection during transport	Θ	▲	Θ		Θ	Θ	O	O	4	5	4	4	5						
3	9	10.5%	4	Handling and Ease of Use	Θ	Θ			▲			Θ	3	5	3	3	5						
4	9	13.2%	5	Sustainable/Recyclable	Θ	Θ	▲	Θ	Θ	Θ	O	Θ	3	5	3	5							
5	9	7.9%	3	Aesthetic Appeal	Θ				O			O	2	4	2	4	4						
6	9	13.2%	5	Low Cost	Θ	O		O	Θ			Θ	4	5	2	5	3						
7	9	13.2%	5	Cube Utilization	▲			Θ	O	Θ	Θ	Θ	1	5	2	3	4						
8	9	10.5%	4	Retail ready secondary tray package	Θ	Θ		Θ	Θ	Θ	Θ	Θ	1	1	1	1	1						
9	9	10.5%	4	Low shelf space utilization				O	O			Θ	1	4	1	3	3						
				Target or Limit Value	none	none	none	none	none	none	none	none											
				Difficulty																			
				Max Relationship Value in Column	9	9	9	9	9	9	9	9											
				Weight / Importance	652.6	360.5	131.6	402.6	563.2	450	292.1	710.5											
				Relative Weight	18.3%	10.1%	3.7%	11.3%	15.8%	12.6%	8.2%	19.9%											

Legend		
Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	

Appendix 3 - Wal-Mart Scorecard

Wal-Mart Scorecard Software:

Given below is the screen shot of the Wal-Mart scorecard software. The software consists of three sections as given below:

1. **Background and Product Info:**

   In this section, general information regarding the product is filled out. This section consists of questions, which are basic in nature and pretty straightforward to answer

2. **Selling Unit Packaging Materials:**

   This section requires information on the primary package components like bottle material and weight, cap material and weight, distance travelled, and primary package cube utilization.

3. **Transport Packaging Materials:**

   This section requires information on the secondary and tertiary package components like corrugated tray material and weight, pallet material and weight, selling units shipped, distance travelled, and transport cube utilization.

Wegmans Barbecue Sauce Project:

The Wal-Mart scorecard is a great tool and will be used for evaluating the alternative designs that were generated for the barbecue sauce bottle. For each design concept, we will need to calculate the Selling Unit Cube Utilization and Transport Cube Utilization in order to input those values in Sections 2 and 3 of the Wal-Mart scorecard software, respectively. The formulas for calculating SUCU and TCU are given below.

$$SUCU = \frac{Product\ Volume}{Primary\ Package\ Volume}$$

$$TCU = \frac{Selling\ Unit\ Volume\ x\ Number\ of\ bottles}{pallet\ volume\ *}$$

*Note: Standard GMA pallet is considered to calculate Pallet Volume (48 x 40 x 52) for TCU

This will be done for the two designs that are being evaluated in reference to the Current Wegmans Glass Bottle. Please see below for the calculations and Wal-Mart Scorecard Software screen shots for each package. The screen shots walk you through the process of finalizing a package design using Wal-Mart Scorecard Software.

Inputs - Wegmans Glass Bottle

Background & Product Info.	
Vendor Number?	
Wal-Mart/Sam's Club Item Number?	
Product UPC?	
What is the item descriptions? (20 characters)	Old Wegmans BBQ Sauce 19oz
What is the consumer meaningful unit of measure (CMUM)?	19 Fluid ounce
What Folder does this reside in?	Final Comparison End Use_2_17_2012
Date of Package Launch? (mm/dd/yyyy)	
What was the purchasing company?	---
What is the estimated number of items sold to the above purchaser?	
What is the primary product department/category?	
Testing was conducted and the new package performance is:	Parity to current
Selling Unit Packaging Materials	
What is the percentage of cube utilization?	.51
How many selling unit packaging materials are used?	4 Material(s)
What is the first packaging material?	Glass
↳ What is the total weight per package for this material?	0.615 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second packaging material?	Aluminum
↳ What is the total weight per package for this material?	0.005 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the third packaging material?	PVC (Polyvinyl chloride)
↳ What is the total weight per package for this material?	0.001 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the fourth packaging material?	Supercalendered (e.g., newspaper inserts)
↳ What is the total weight per package for this material?	0.002 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers

Transport Packaging Materials	
Is this item a break pack?	○ Yes ◉ No
What is the percentage of cube utilization?	.67
How many materials are used to transport the selling unit package?	3 Material(s)
What is the shipping platform for this package?	Wood pallet: GMA - 48x40 pooled/reusable pallet
↳ How many selling units are shipped in this transport packaging?	1008
↳ What is the total weight per package for this material?	50 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second material used in transporting?	Corrugated: Unbleached
↳ How many selling units are shipped in this transport packaging?	1008
↳ What is the total weight per package for this material?	0.595 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the third material used in transporting?	Paperboard: Uncoated Recycled (URB)
↳ How many selling units are shipped in this transport packaging?	1008
↳ What is the total weight per package for this material?	0.315 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers

Wegmans Glass Calculations:

$$\boldsymbol{SUCU} = \frac{\boldsymbol{ProductVolume}}{\boldsymbol{PrimaryPackageVolume}} = \frac{34.28906}{67.41}$$

=50.85%

$$TCU = \frac{SUV\ x\ Numberofbottles}{pallet\ volume}$$

$$= \frac{7.125 \text{ x } 3.0625 \text{ x } 3.0625 \text{ x } 1008}{99840}$$

= 67.46%

*Note: SUCU is Selling Unit Cube Utilization and TCU means Transport packaging Cube Utilization

Inputs – Concept 4:

Background & Product Info.	
Vendor Number?	
Wal-Mart/Sam's Club Item Number?	
Product UPC?	
What is the item descriptions? (20 characters)	Concept 4
What is the consumer meaningful unit of measure (CMUM)?	19 Fluid ounce
What Folder does this reside in?	Final Comparison End Use_2_17_2012
Date of Package Launch? (mm/dd/yyyy)	
What was the purchasing company?	---
What is the estimated number of items sold to the above purchaser?	
What is the primary product department/category?	
Testing was conducted and the new package performance is:	Parity to current
Selling Unit Packaging Materials	
What is the percentage of cube utilization?	0.70
How many selling unit packaging materials are used?	4 Material(s)
What is the first packaging material?	PET, PETE (Polyethylene terephthalate)
↳ What is the total weight per package for this material?	0.085 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second packaging material?	PP (Polypropylene)
↳ What is the total weight per package for this material?	0.005 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the third packaging material?	HDPE
↳ What is the total weight per package for this material?	0.010 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the fourth packaging material?	Supercalendered (e.g., newspaper inserts)
↳ What is the total weight per package for this material?	0.001 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers

Transport Packaging Materials	
Is this item a break pack?	○ Yes ◉ No
What is the percentage of cube utilization?	.65
How many materials are used to transport the selling unit package?	3 Material(s)
What is the shipping platform for this package?	Wood pallet: GMA - 48x40 pooled/reusable pallet
↳ How many selling units are shipped in this transport packaging?	1320
↳ What is the total weight per package for this material?	50 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second material used in transporting?	Corrugated: Unbleached
↳ How many selling units are shipped in this transport packaging?	1320
↳ What is the total weight per package for this material?	0.245 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the third material used in transporting?	PVC (Polyvinyl chloride)
↳ How many selling units are shipped in this transport packaging?	1320
↳ What is the total weight per package for this material?	.005 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers

Concept 4 Bottle Calculations:

$$\boldsymbol{SUCU} = \frac{\boldsymbol{ProductVolume}}{\boldsymbol{PrimaryPackageVolume}} = \frac{34.28906}{49.246}$$

=69.62%

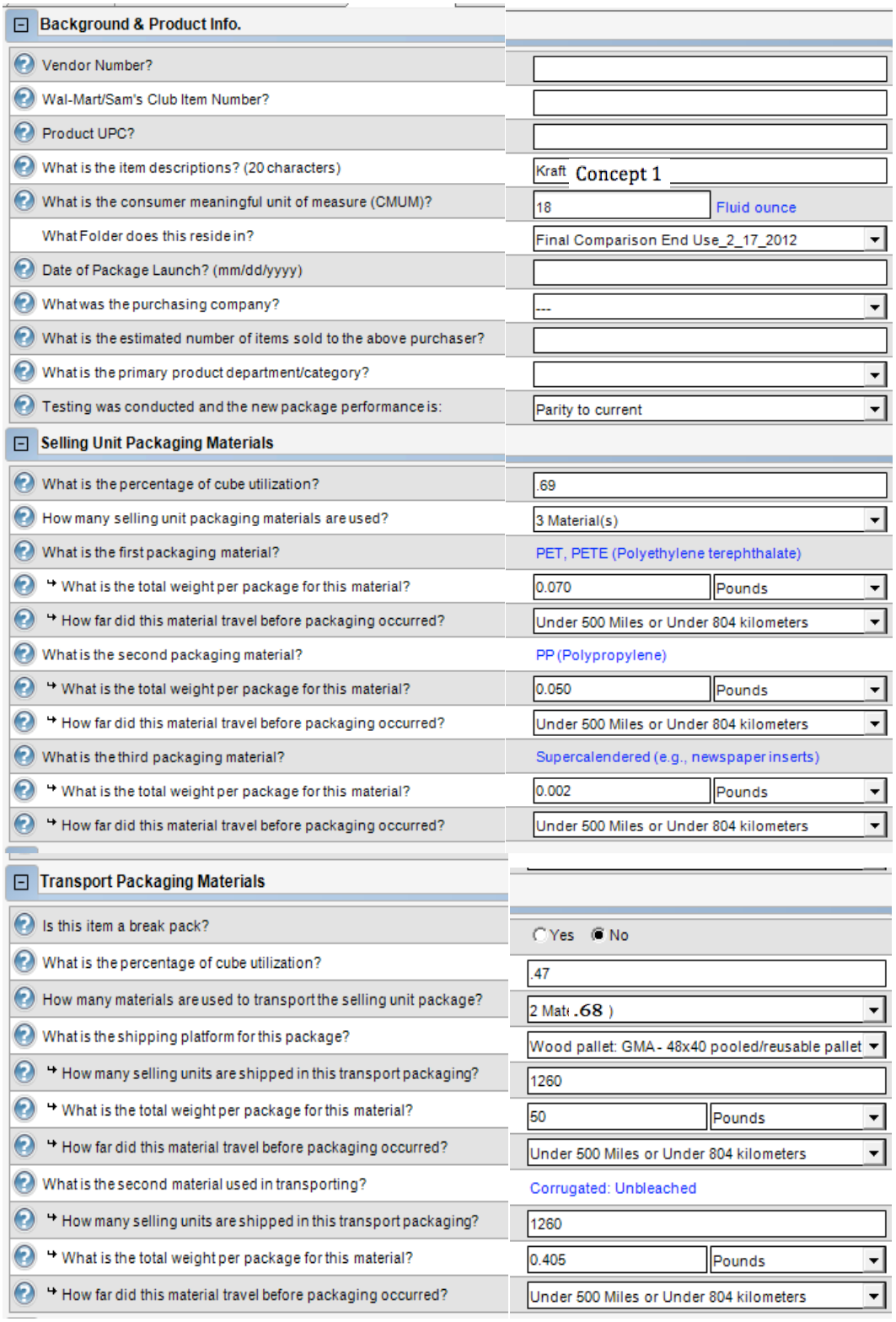
$$TCU = \frac{SUV x Number of bottles}{pallet\ volume}$$

$$= \frac{7.875 \text{ x } 3.3 \text{ x } 1.895 \text{ x } 1320}{99840}$$

= 65.10%

*Note: SUCU is Selling Unit Cube Utilization and TCU means Transport packaging Cube Utilization

Inputs – Concept 1:



Background & Product Info.	
Vendor Number?	
Wal-Mart/Sam's Club Item Number?	
Product UPC?	
What is the item descriptions? (20 characters)	Kraft Concept 1
What is the consumer meaningful unit of measure (CMUM)?	18 Fluid ounce
What Folder does this reside in?	Final Comparison End Use_2_17_2012
Date of Package Launch? (mm/dd/yyyy)	
What was the purchasing company?	---
What is the estimated number of items sold to the above purchaser?	
What is the primary product department/category?	
Testing was conducted and the new package performance is:	Parity to current
Selling Unit Packaging Materials	
What is the percentage of cube utilization?	.69
How many selling unit packaging materials are used?	3 Material(s)
What is the first packaging material?	PET, PETE (Polyethylene terephthalate)
↳ What is the total weight per package for this material?	0.070 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second packaging material?	PP (Polypropylene)
↳ What is the total weight per package for this material?	0.050 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the third packaging material?	Supercalendered (e.g., newspaper inserts)
↳ What is the total weight per package for this material?	0.002 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
Transport Packaging Materials	
Is this item a break pack?	○ Yes ◉ No
What is the percentage of cube utilization?	.47
How many materials are used to transport the selling unit package?	2 Mat(.68)
What is the shipping platform for this package?	Wood pallet: GMA - 48x40 pooled/reusable pallet
↳ How many selling units are shipped in this transport packaging?	1260
↳ What is the total weight per package for this material?	50 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers
What is the second material used in transporting?	Corrugated: Unbleached
↳ How many selling units are shipped in this transport packaging?	1260
↳ What is the total weight per package for this material?	0.405 Pounds
↳ How far did this material travel before packaging occurred?	Under 500 Miles or Under 804 kilometers

Concept 1 Calculations:

$$\textbf{SUCU} = \frac{\mathrm{Pr}oductVolume}{\mathrm{Pr}imaryPackageVolume}$$

$$= \frac{32.48}{47.22}$$

$$= 68.782\%$$

$$\textbf{TCU} = \frac{SUVxNo.OfBottles}{PalletVolume}$$

$$= \frac{7.75x3.25x1.875x1440}{99840}$$

$$= 68.11\%$$

*Note: SUCU is Selling Unit Cube Utilization and TCU means Transport packaging Cube Utilization

Scorecard Metrics

Given below is the table generated by the Wal-Mart scorecard software showing the performance of the package for each metric. From the table below, it is very clear that Concept 4 is the winner since it has the highest weighted average score of 8.75 and is way better than current Wegmans Glass bottle. Concept 4 is 19% more cube efficient, has 95% reduction in package to product ratio, as compared to the baseline (Wegmans Glass Bottle). It is therefore recommended to pursue Concept 4 for full-scale production.

Package	CO2	Sustainable Material	Package/Product Ratio	Cube Utilization	Recovery	Weighted Average
Concept 4	0.0002	0.1868	0.1868	0.6962	0.5714	8.7500
Concept 1	0.0002	0.2372	0.2372	0.6878	0.8101	6.0000
Wegmans Glass Bottle	0.0004	1.1227	1.1192	0.5085	2.2604	0.0000

After finalizing the design with the Wal-Mart scorecard, it is now necessary to understand the transportation savings and how this new package design will help the retailer to optimize the shelf storage. This is done by using the next tool called the CAPE analysis.

Appendix 4 - Cape Palletization Software

The CAPE palletization software is a great tool and will be used for demonstrating the truckload analysis of the Wegmans glass bottle and the PET bottle (Concept 4 package). For each bottle, we will need to calculate the secondary package dimensions and secondary package weight. These values will serve as a input to calculate the pallet load. Please see individual sections below for each package

Given below is a step-by-step process to calculate the truckload for the secondary packages. Below is the screen shot of the CAPE software. The software consists of two sections as given below:

1. **Case Information:**

In this section, the information related to the secondary package like dimensions and weight will be entered. This information can be retrieved from the calculations performed above. For the Wegmans glass bottle, we already had that information, and there was no need to calculate the dimensions and weight for the secondary package.

2. **Pallet Information:**

In this section, information related to pallet, such as the pallet style weight of the pallet, will be entered. The pallet style commonly used in the industry is 48 x 40 Standard GMA pallet. The weight of the pallet is 50 lbs.

Wegmans Glass CAPE software:

CAPE Calculations for Wegmans Glass Bottle:

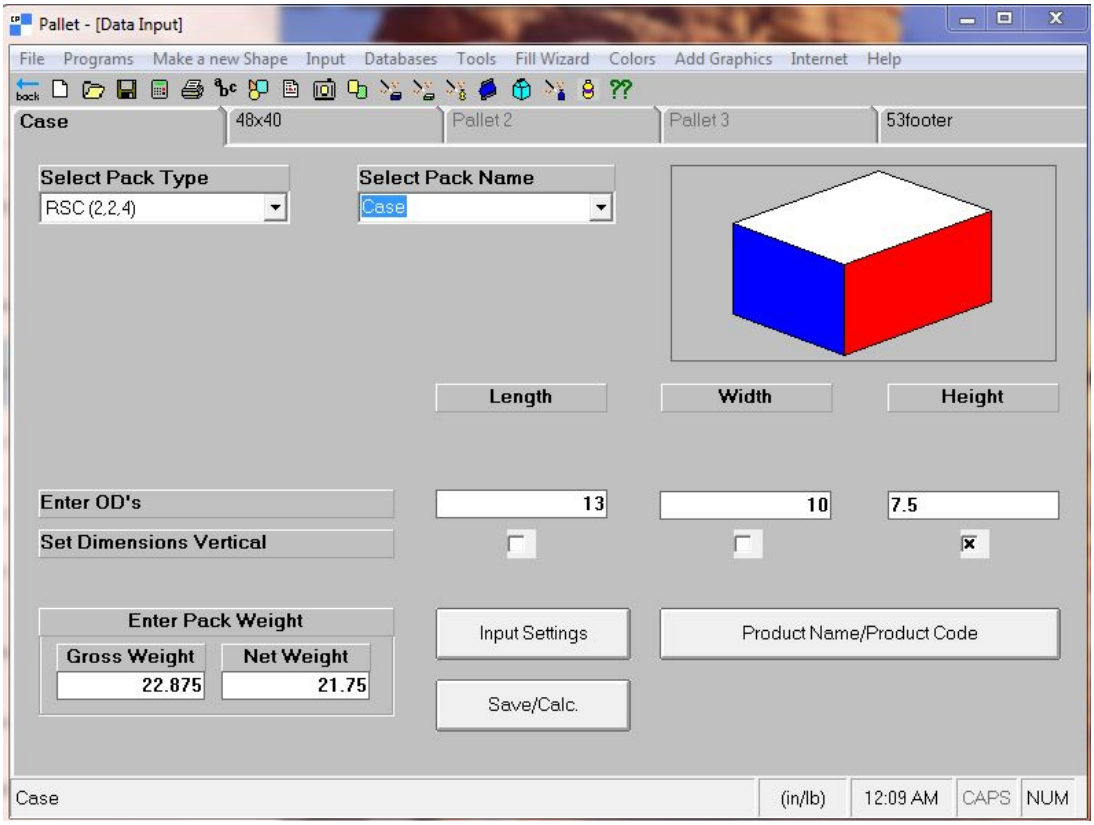
Since this package is our current package, we do not need to calculate the secondary package dimensions and secondary package weight. We already have those. Please see below.

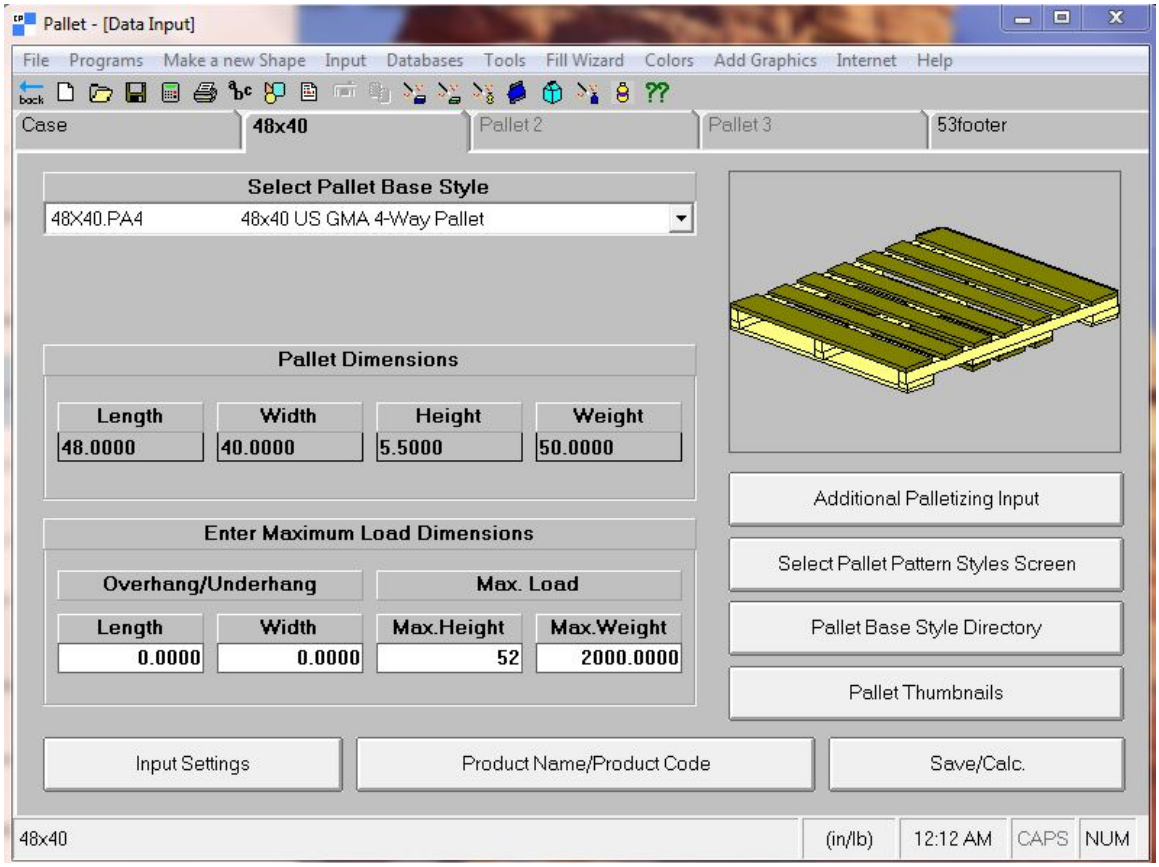
Secondary package dimensions: **13 x 10 x 7.5 in**

Secondary package weight:

Net weight (weight of product) – **21.75 lbs**

Gross Weight (weight of product + secondary package weight) – **22.815 lbs**

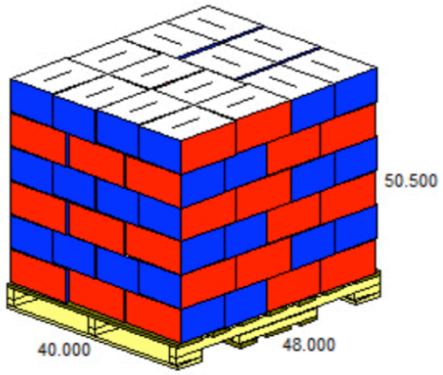


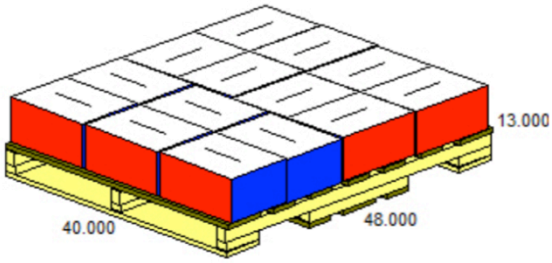


Based on the inputs provided to the software, the software generated a report as shown below

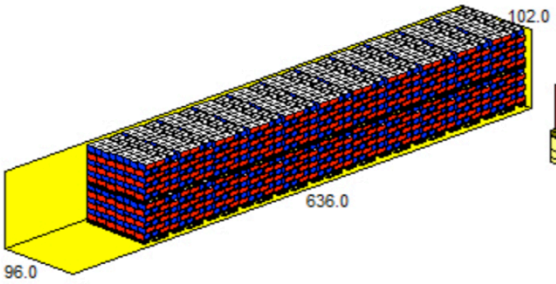
Bottles/Case	12
Case/Layer	14
Layer/Load	6
Case/Load	84
Bottles/Load	1008
Pallets/Truck	44
Bottles/Truck	44352

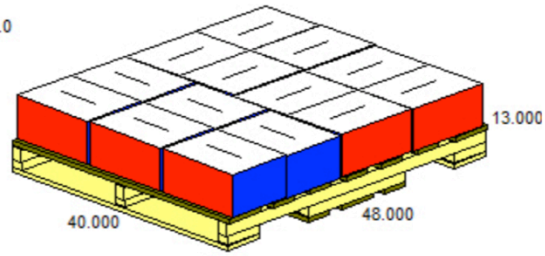
		Length	Width	Height		Net	Gross	
Case	(OD)	13.000	10.000	7.500	in	21.750	22.815	lb
Product		46.000	40.000	45.000	in	1827.000	1916.460	lb
Load		48.000	40.000	50.500	in	1916.460	1966.460	lb





		Length	Width	Height		Net	Gross	
Case	(OD)	13.000	10.000	7.500	in	21.750	22.815	lb
Product		46.000	40.000	45.000	in	1827.000	1916.460	lb
Load		48.000	40.000	50.500	in	1916.460	1966.460	lb
Product		528.000	80.000	101.000	in	84324.2	86524.2	lb
53footer		636.000	96.000	102.000	in	86524.2	96524.2	lb





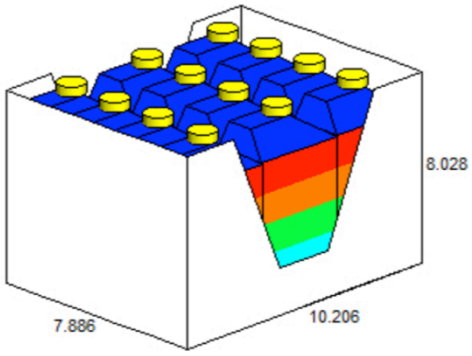
Wegmans PET Bottle (Concept 4) CAPE Software:

CAPE Calculations for Wegmans PET Bottle:

Since this package is our new package, we will need to calculate the secondary package dimensions and secondary package weight.

The primary package dimensions are 7.8750 x 3.3 x 1.8950.

Based on these dimensions secondary package was designed. Please note that the configuration (12 bottles per case) was kept constant. The package was precisely designed, as shown below.



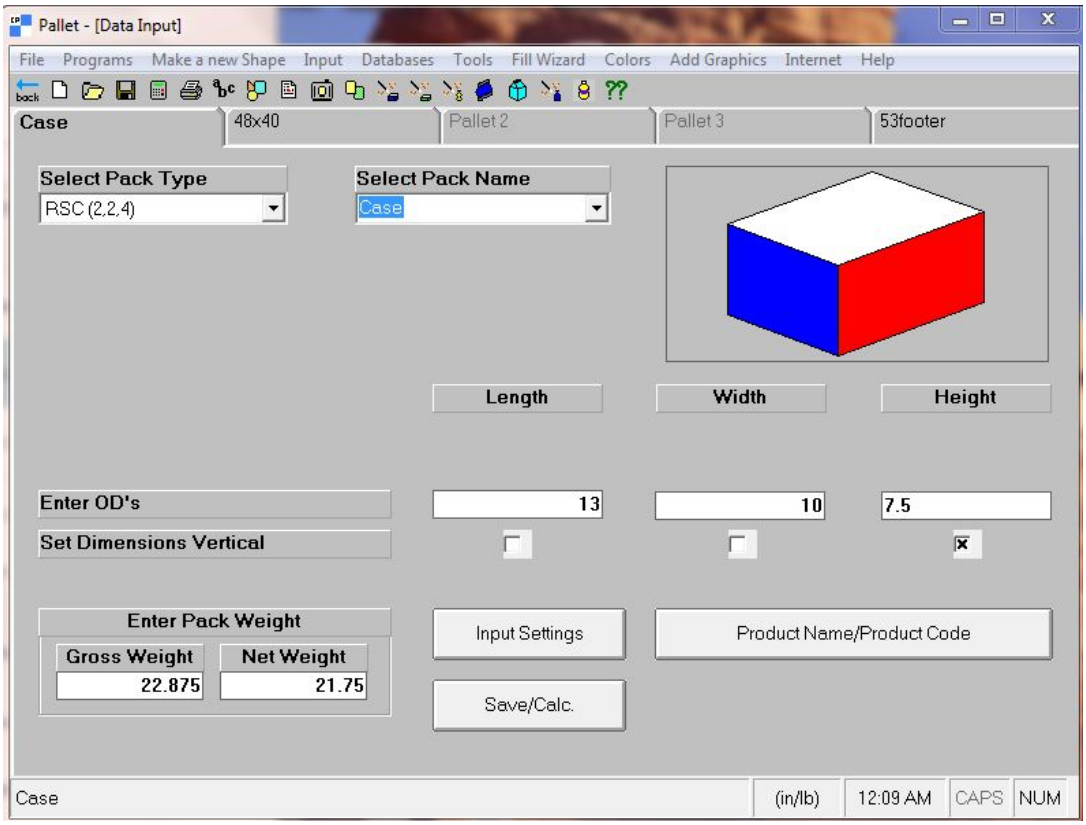
Secondary package dimensions: **10.206 x 7.886 x 8.028 in**

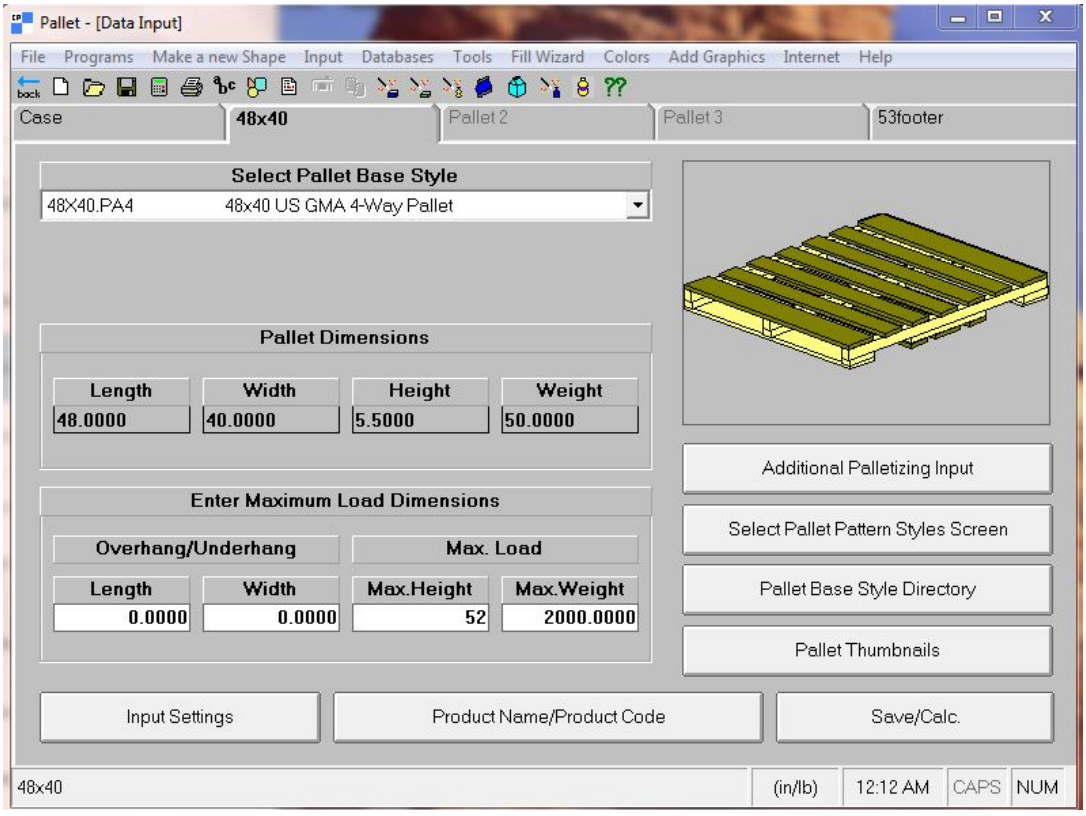
Secondary package weight:

Net weight (weight of product) – **15.45 lbs**

Gross Weight (weight of product + secondary package weight) – **15.791 lbs**

This information was then entered in the software as shown below:

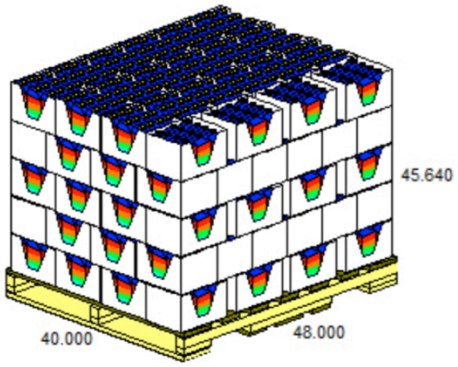

Pallet - [Data Input]
File Programs Make a new Shape Input Databases Tools Fill Wizard Colors Add Graphics Internet Help
Case
48x40
Pallet 2
Pallet 3
53footer
Select Pack Type
RSC (2,2,4)
Select Pack Name
Case
Length
Width
Height
Enter OD's
13
10
7.5
Set Dimensions Vertical
Enter Pack Weight
Gross Weight
Net Weight
22.875
21.75
Input Settings
Product Name/Product Code
Save/Calc.
Case
(in/lb)
12:09 AM
CAPS
NUM

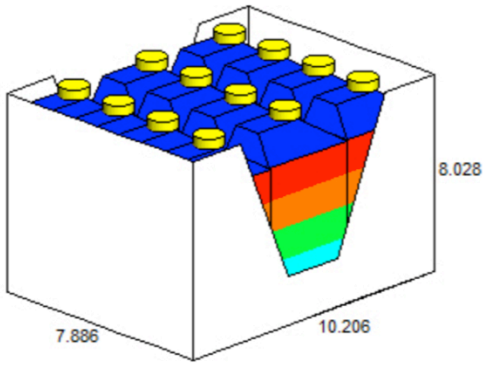

Pallet - [Data Input]
File Programs Make a new Shape Input Databases Tools Fill Wizard Colors Add Graphics Internet Help
Case
48x40
Pallet 2
Pallet 3
53footer
Select Pallet Base Style
48X40.PA4
48x40 US GMA 4-Way Pallet
Pallet Dimensions
Length
Width
Height
Weight
48.0000
40.0000
5.5000
50.0000
Enter Maximum Load Dimensions
Overhang/Underhang
Max. Load
Length
Width
Max.Height
Max.Weight
0.0000
0.0000
52
2000.0000
Additional Palletizing Input
Select Pallet Pattern Styles Screen
Pallet Base Style Directory
Pallet Thumbnails
Input Settings
Product Name/Product Code
Save/Calc.
48x40
(in/lb)
12:12 AM
CAPS
NUM

Based on the inputs provided to the software, the software generates a report as shown below:

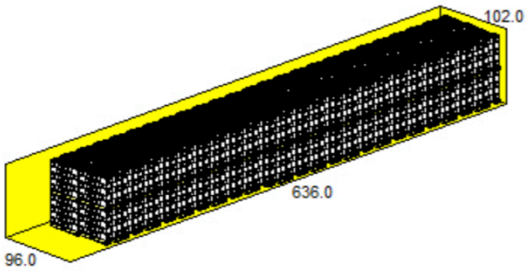
Bottles/Case	12
Case/Layer	22
Layer/Load	5
Case/Load	110
Bottles/Load	1320
Pallets/Truck	48
Bottles/Truck	63360

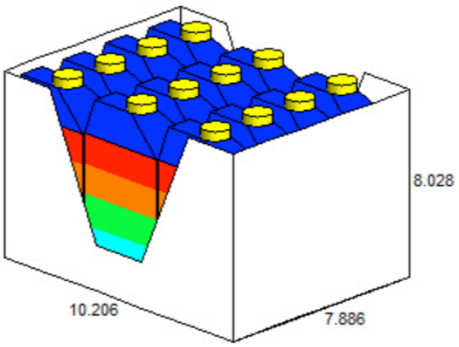
	Length	Width	Height		Net	Gross	
Rectangu (OD)	3.300	1.895	7.875	in	1.188	1.288	lb
Tray (OD)	10.206	7.886	8.028	in	15.450	15.791	lb
Product	47.284	38.465	40.140	in	1699.500	1737.010	lb
Load	48.000	40.000	45.640	in	1737.010	1787.010	lb





	Length	Width	Height		Net	Gross	
Rectangu (OD)	3.300	1.895	7.875	in	1.188	1.288	lb
Tray (OD)	10.206	7.886	8.028	in	15.450	15.791	lb
Product	47.284	38.465	40.140	in	1699.500	1737.010	lb
Load	48.000	40.000	45.640	in	1737.010	1787.010	lb
Product	576.000	80.000	91.280	in	83375.6	85775.6	lb
53footer	636.000	96.000	102.000	in	85775.6	95775.6	lb

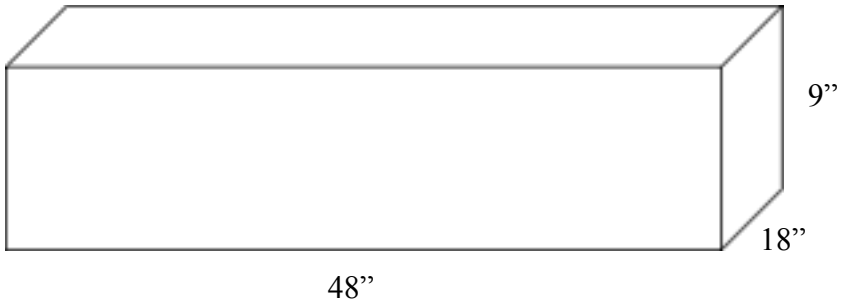




Appendix 5 - Shelf Space Utilization

Store Shelf Optimization:

Store shelf dimensions



*Store shelf display size is per Wegmans information, and we would be using this size for the calculations below:

Wegmans Glass Bottle

48" wide / 3.0625" per bottle = 15 bottles across 18" deep / 3.0625" per bottle = 5 bottles deep Total bottles on shelf = 75 bottles

Wegmans Proposed Plastic Bottle

48" wide / 3.3" per bottle = 14 across 18" deep / 1.895" per bottle = 9 bottles deep Total bottles on shelf = 126 bottles per shelf

1- (75/126) = .41 41% increase in shelf storage

Appendix 6 - ASTM D7386-12 Distribution Conditioning

Contained within this appendix are the results for testing Wegmans barbecue sauce-finished package.

Pre Test Inspections:

The components used for this test were inspected before subjecting them to distribution testing as per ASTM D7386. All the components appeared to be brand new and showed no signs of damage.

Test Plan:

ASTM D7386 "Standard Practice for Performance Testing of Packages for Single Parcel Delivery" was used to evaluate the mechanical performance of the Wegmans barbecue sauce.

- Assurance Level 2 was used to simulate the worst-case condition. The test samples are classified as "TS-4 All Other Packaged-Products", based on the size, weight, and form of construction defined in ASTM D7386.
- TS-4 will subject the barbecue sauce package to the following conditioning test sequences:
    - Schedule A1 – Mechanical Handling
    - Schedule D1 – Vibration Under Compressive Load
    - Schedule A2 – Mechanical Handling
    - Schedule D3 – Vibration Without a Compressive Load
    - Schedule A3 – Mechanical Handling

Schedule A1 - Handling:

Since the package weighs less than 70lbs, the following test sequence was followed:

Orientation	A.L. II
Edge 3–4	14 in. (356 mm)
Edge 3–6	14 in. (356 mm)
Corner 3–4–6	14 in. (356 mm)
Face 3	14 in. (356 mm)
Corner 2–3–5	20 in. (508 mm)
Edge 4–6	20 in. (508 mm)

Schedule D1 - Vibration under Compressive Load:

The compressive load is calculated according to the formula given below:

$$Compressive\ Load\ (L) = Mf \times J \times ((l \times w \times h) / K) \times ((H - h) / h) \times F$$

Where:

L = minimum required test load = lb. (N),

Mf = shipping cargo density factor = 12.0 lb./ft^3 (192.22 kg/m3),

J = conversion factor = 1 lbf per lb. (9.8 N/kg),

l = length of shipping unit = in. (m),

w = width of shipping unit = in. (m),

K = conversion factor = 1728 in.^{3}/ft^3 (1 m3/1 m3),

H = maximum stack height = 108.0 in. (2.74 m),

h = height of shipping unit as tested = in. (m), and

F = 0.5

Orientation	Duration	Calculated Compressive Load	Actual Compressive Load
Face 3 down	60 mins	27.93 lbs.	28 lbs.
Face 2 down	30 mins	21.49 lbs.	Since the compressive load is less than 25lbs, we will not be using it during the test as per ASTM D7386 guidance
Face 5 down	30 mins	28.47 lbs.	29 lbs

Schedule A2 - Mechanical Handling

Since the parcel weighs less than 70lbs, the following test sequence was followed:

Orientation	A.L. II
Edge 2–3	20 in. (508 mm)
Corner 2–3–6	20 in. (508 mm)
Edge 2–5	14 in. (356 mm)
Edge 3–5	14 in. (356 mm)
Corner 3–4–5	14 in. (356 mm)
Face 1	14 in. (356 mm)

Schedule D3 - Vibration without the Compressive load:

The test specimen is centered on the vibration table with Face 3 of the test specimen in the down orientation. The test is performed for 30 min using the random vibration profile.

Schedule A3 - Mechanical Handling:

Since the parcel weighs less than 70lbs, the following test sequence was followed:

Orientation	A.L. II
Edge 1–2	14 in. (356 mm)
Corner 1–4–6	14 in. (356 mm)
Edge 3–4	20 in. (508 mm)
Edge 3–6	20 in. (508 mm)
Corner 3–4–6	20 in. (508 mm)
Face 3	32 in. (813 mm)

Acceptance Criteria and Test Results

Testing Method (not validated)	Test/Inspection Criteria	Attributes	Min. Sample Size	Accept/ Reject	Pass/ Fail
Visual	Tamper Evidence feature compromised	Tamper Evidence feature should not be compromised	12	12/ 0	Pass (12/0)
	Broken Bottle	The contents of the package should not leak	12	12/ 0	Pass (12/0)
	Smudging, and smearing observed on the graphics	The graphics must be free from smudging	12	12/0	Pass (12/0)
	Secondary Corrugated tray containment	The bottles must remain in the tray and must not fall out	12	12/0	Pass (12/0)

Post Test Inspections/ Observations

After subjecting the barbecue sauce package to ASTM D7386-12, the bottles were visually inspected for the inspection criteria as described in Acceptance Criteria. It was observed that all the bottles passed the test. No broken bottles were observed. The graphics showed no signs of damage. The product was contained within the secondary tray. The tamper evidence feature was not compromised on any of the bottles.

Conclusion

The testing was successfully performed using the Wegmans PET bottle (Concept 4). From the observations, it is clear that the new bottle design and the corrugated tray design has successfully met the acceptance criteria for the distribution tests.

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